ADVANCES
IN CHILD DEVELOPMENT
AND BEHAVIOR

VOLUME 2

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ADVANCES IN CHILD DEVELOPMENT AND BEHAVIOR

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Preface

During the past decade or so, the field of child development and behavior has experienced a rapid increase in the number of research and theoretical publications. Use of original sources by scientists and students in maintaining a scholarly knowledge both within and outside their areas of specialization has become a most formidable task.

The serial publication of *Advances in Child Development and Behavior* is intended to provide scholarly reference articles in the field and to serve two other purposes. On the one hand, it is hoped that teachers, research workers, and students will find these critical syntheses useful in the endless task of keeping abreast of growing knowledge in areas peripheral to their primary focus of interest. There is currently an indisputable need for technical, documented reviews which would facilitate this task by reducing the frequency with which original papers must be consulted, particularly in such secondary areas. On the other hand, the editors are also convinced that research in child development has progressed to the point that such integrative and critical papers will be of considerable usefulness to researchers within problem areas with which they are *primarily* concerned.

The editors are making no attempt to organize each volume around a particular topic or theme. Rather, they solicit manuscripts from investigators conducting programmatic research on problems of current interest. They will often encourage the preparation of critical syntheses dealing intensively with topics of relatively narrow scope but of potentially considerable interest to the scientific community.

Although appearance in the volumes is ordinarily by invitation, unsolicited manuscripts will be welcomed for review if submitted in outline form.

The writers wish to acknowledge with gratitude the aid of Mrs. Sara Montgomery, who assisted in the indexing and collating of materials for this volume. Appreciation is also expressed to the institutions which generously provided the editors with time and facilities to produce these volumes.

April, 1965

LEWIS P. LIPSITT
CHARLES C. SPIKER

Contents

THE PAIRED-ASSOCIATES METHOD IN THE STUDY OF CONFLICT[1]

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I. Introduction

The experiments to be described in the following sections were initiated by earlier, casual observations of the intra-list, or within-*S*s, method of producing associative transfer in the paired-associates experiment. More specifically, these observations suggested that the within-*S*s method for varying such factors as associative strength and associative interference, while efficient from the view-

[1] The research described herein was made possible by a National Institute of Mental Health grant (M-4240).

point of experimental design, introduce other unanticipated and psychologically complicating factors. In the course of this work, all of which involved elementary school age children, the notion that these factors may be essentially motivational (nonassociative) in some of their characteristics guided our interests. More basically, these studies are concerned with the general proposition that conditions which produce associative interference, that is, competition between incompatible response tendencies, may serve to engender motivational states in the *S*.

II. Theoretical and Methodological Considerations

The notion of response-tendency competition has been central in the theoretical analyses of the phenomena of conflict of such writers as Lewin (1933), Miller (1944), and Brown and Farber (1951). Of particular interest to the presently reviewed studies is the suggestion by these writers that conflict, i.e., competition of response tendencies, may provide a source of motivation in addition to those other motivational sources upon which the competing responses are based. According to this suggestion, if an overt response has been initially aroused in competition with another, the motivational (energizing) effect of the conflict- or competition-produced motivational state might be expected to be reflected in some measure of its vigor.

Most studies concerned with the simultaneous arousal of incompatible responses have been primarily interested in their relation to the diminution in vigor of the overt response as reflected in such phenomena as lengthening of its latency, blocking, vacillation, etc. Two studies will be described first, in order to illustrate several important methodological considerations pertaining to such investigations. Both studies, one with rats (Finger, 1941) and one with human adults (Castaneda & Worrell, 1961), were concerned with assessing the hypothesis of conflict-produced energizing states by arranging the conditions of measurement so as to minimize the inhibiting influence of the competing tendency on the overt response.

Finger studied the effect of degree of similarity between the positive and negative cues on the performance of rats in a brightness discrimination in a jumping stand. He found that stimulus similarity had one effect on the latency, and a different effect on the force, of the jump response. Following simple instrumental conditioning procedures with the positive stimulus, differences in similarity between the two cues were introduced during discrimination training. Latency of the jump response was shown to lengthen with increased similarity, a finding which is in accord with the assumption that the greater the generalization between cues, the greater the degree of competition between responses. The force of the jump response, on the other hand, was shown to *increase* with

increased stimulus similarity. This finding is consistent with the hypothesis that the level of drive dependent on simultaneously aroused incompatible responses is inversely related to the magnitude of the difference in strength between them (Brown & Farber, 1951).

Castaneda and Worrell (1961) extended Finger's basic procedure to motor conflict in adult human *S*s. Thus, by means of simple motor responses whose latency and amplitude (grip pressure) were recorded, human *S*s were required to make brightness discriminations over a series of trials. Different groups discriminated between brightness values separated by differences of either 2.0 or .50 log units. Their results were consistent with those reported by Finger. Latency was found to be reliably longer the smaller the difference between brightnesses; grip pressures were in the opposite direction, i.e., they were reliably higher the smaller the difference. Furthermore, the effect on grip pressure was shown to be independent of errors in discrimination. As will be shown below, the latter finding provides some information about the effects of an error in the within-*S*s design.

In the case of the Castaneda and Worrell study, it could be argued that frequency of errors in discrimination increases with heightened similarity between the stimuli and that the occurrence of such errors produces, through anxiety or frustration, enhanced vigor of the selective, motor response. If this argument were correct, it would be impossible to attribute the enhanced vigor of responding solely to a conflict-produced increase in motivation. The argument is especially plausible in experiments that employ relatively short intertrial intervals, where an increase in response vigor on a given trial could reflect the effects of an error on the preceding trial.

III. The Within-*S*s Design

The first experiment to be described was conducted by Odom (1960), and the findings have been replicated in three subsequent studies by Castaneda and Odom (1961), McCullers (1963), and Koppa (1960). The conditions of this experiment permit an opportunity to evaluate an hypothesis implicit in the within-*S*s method for varying the factors of associative strength and the degree of competition in paired-associates learning. This method, originally proposed by Spence (1956), involves constructing a paired-associates list such that the presence of competing associations is maximized for some of the items comprising the list but minimized for the others. The basic feature of this method is diagrammed as Condition I in Fig. 1, where it may be compared with a control, Condition II.

In Fig. 1, strong initial associative connections are depicted by solid shafted arrows (e.g., between S_A and R_A), and weak initial associative connections are

represented by arrows with broken shafts (e.g., between $S_{A'}$ and R_B). It is expected, of course, that early performance would be better on the strongly associated pairs than on pairs with weak associations. Functional similarity between items such as synonyms and antonyms is indicated by means of the prime sign. Assuming that associations generalize between stimuli S_A and $S_{A'}$ in Condition I, the learning of weaker associations ($S_{A'} \dashrightarrow R_B$) would be impaired, relative to the corresponding pair ($S_C \dashrightarrow R_B$) in Condition II, because of interference generated by the initially strong tendency for $S_{A'}$ to evoke R_A.

As implied earlier, however, the basic interest is in the hypothesis that as the initially weak association between $S_{A'}$ and R_B is gradually strengthened through learning, it generalizes to produce an association between S_A and R_B. This assumption has been invoked by Lovaas (1960), Ramond (1953),

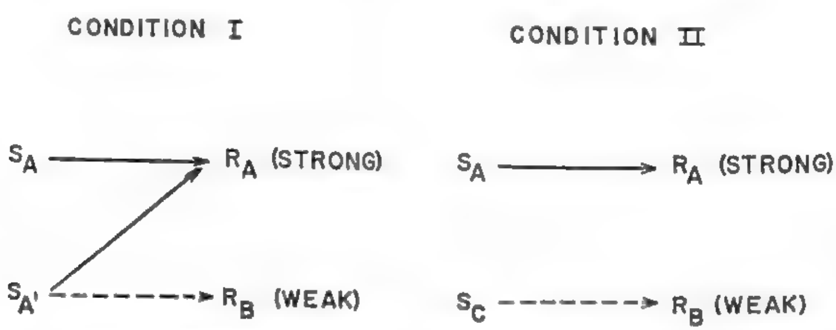

Fig. 1. Schematic representation of the competitive and noncompetitive to-be-learned S-R associations.

Spence, Farber, and McFann (1956), and Spence, Taylor, and Ketchel (1956) to account for the consistent finding that a heightened level of motivation, produced either by induced muscular tension or inferred from scores on the Taylor Manifest Anxiety Scale, results in superior performance on the $S_A \rightarrow R_A$ pairs during the early trials, but eventually leads to poorer performance, relative to a lower motivational condition, at later stages of learning. The interest in the Odom experiment was to assess the hypothesis of the development of a generalized association between S_A *and* R_B in Condition I by comparing performance on the $S_A \rightarrow R_A$ pairs with that in Condition II. If the stimulus (S_C) of the initially weak-associated S-R pair in Condition II is selected so as to minimize generalization to S_A, the formation of the association $S_A \rightarrow R_A$ would be expected to be faster in Condition II than in Condition I, even though the association is initially strong in both conditions.

The paired-associates lists were constructed in accord with the diagram shown in Fig. 1, and the experimental words are presented in Table I along with the association values existing between the associates. These words were drawn

from a list described elsewhere by Castaneda, Fahel, and Odom (1961). Association value or strength between a pair of words is defined as the percentage of fourth, fifth, and sixth grade *S*s who gave the same response as an association during an 8-sec interval in that study.

Three sets of word pairs were employed for each condition, each set having one strong and one weak association-value word pair. A set consisted of an asterisked pair and the pair immediately below it. The sets were so constructed that both Conditions I and II had the same stimulus words for the strong association-value pairs, and the same response words were used for all pairs. Association values, which are given in parentheses, are expressed in percentages for each S-R pair, e.g., *beautiful-ugly* (24%). The percentages indicated after each stimulus word of the weak association-value pairs in Condition I represent

TABLE I
COMPETITIVE AND NONCOMPETITIVE WORD PAIRS FOR THE ODOM EXPERIMENT AND ASSOCIATION VALUES

Stimuli		
Condition I	Condition II	Response
*Beautiful	*Beautiful	Ugly (24)
Pretty (24)	Poor	Less (1)
*Warm	*Warm	Cold (35)
Hot (32)	Hurt	Fast (1)
*Little	*Little	Big (34)
Small (23)	Still	More (1)

* Strong association pairs.

the association value between the stimulus word and the response word of the strong association-value pair in its set, e.g., *hot* (32%) *cold*. For each set in Condition II the association-value between the stimulus word of the weak association-value pair and the response word of the strong association-value pair was initially low, i.e., 1%. Furthermore, the inter-set association-values between words were 1%.

The *S*s in this experiment were fourth, fifth, and sixth grade boys and girls. A description of the procedures for paired-associates learning in children of these ages may be found in Castaneda *et al.* (1961). The procedure is essentially similar to that conventionally employed with adult *S*s.

Figure 2 presents performance curves in terms of mean percentage of correct anticipations plotted separately for the strong and the weak association pairs within each condition (I and II). Note that the curves which represent performance on the strong association pairs are higher along the ordinate in com-

parison with the weak association pairs in both conditions. With the exception of Trial 1, the curve for Condition II is higher than the curve for Condition I on the strong association pairs. Condition II also exhibits a higher level of performance than Condition I on the weak association pairs. Indeed, it may be noted that performance on the weak association pairs in Condition II is consistently superior to the strong association pairs of Condition I on Trials 12 through 15. An analysis of the difference in mean percentage of correct anticipations between Conditions I and II on the strongly associated pairs, based

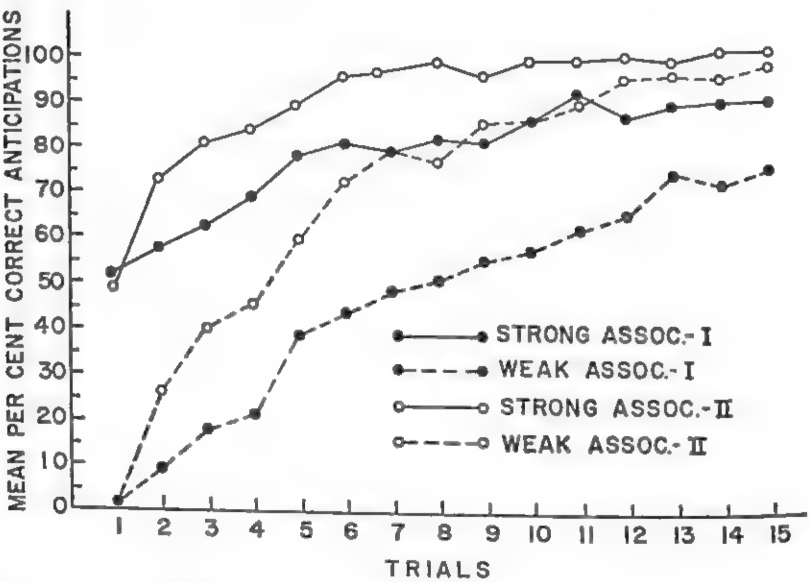

Fig. 2. Mean percentage of correct anticipations plotted separately for the strong and weak association pairs within each condition.

on Trials 2 through 15, was found to be statistically reliable ($p. < .001$). Thus, the finding that performance in Condition II was superior to that of Condition I on those S-R pairs mediated by an initially strong associative connection is consistent with the hypothesis described above.

IV. Sources of Associative Transfer in the Within-*S*s Design

Although the findings in Odom's experiment are consistent with the hypothesis, certain behavioral phenomena have suggested the possibility of other factors which may have contributed to the results. This can be best articulated by reference to Fig. 1. According to the hypothesis, performance on the strong S-R pairs in Condition I is expected to be poorer relative to the corresponding

and identical pairs in Condition II because: (1) the association between $S_{A'}$ and R_B is strengthened through learning, and (2) a *generalized* association is presumed to develop between S_A and R_B. Behavioral evidence consistent with the contribution from generalization would be reflected in the tendency for the *S* to make, as an overt error, R_B in response to S_A. In fact, errors of this type were reported to have occurred in these experiments, but at a very *low* frequency. The most frequent error that has been observed to occur in this connection has been the failure to give any association during the anticipation interval (errors of omission). Assuming the development of the generalized *competing* association, such phenomena appear readily explainable. However, another type of error has been observed to occur with a frequency equal to the overt generalized error. This type consists of responding with the stimulus item in the set, i.e., with $S_{A'}$. Thus, if S_A is the adjective *beautiful,* which is to

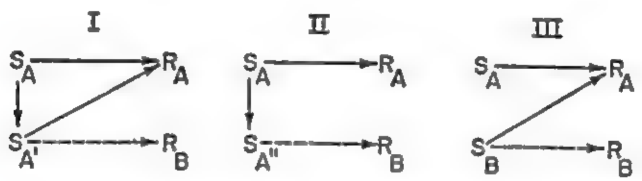

Fig. 3. Schematic representation of the inter-stimulus and S-R associative connections employed in McCullers' study.

be associated to the response *ugly* (R_A), and $S_{A'}$ is the synonym *pretty,* the latter is given as an incorrect association. The occurrence of this type of error, which we shall designate a *stimulus error,* has led us to question where the basic source of competition lies, i.e., in the inter-word pair associative connection implied by the hypothesis, or in the inter-stimulus associative connections.

As mentioned earlier, such results and other observations have suggested some of the complications attending the within-*Ss* design. Consequently, as part of his doctoral research, McCullers (1963) conducted an experiment designed to isolate the relative contributions of these two sources of error in the within-*Ss* design. His method involved constructing lists such that separate lists have only one or the other of the two sources of competition. With Spence's method redrawn to show the inter-stimulus associative connection (Condition I), McCullers' methods are shown in Fig. 3.

It may be noted that in Condition II the stimuli are strongly associated, but there is no strong connection between $S_{A''}$ and R_A. In Condition III, however, both stimuli are strongly associated with R_A but are not associated with each other. With respect to performance on the strong pair, the inter-stimulus associative connection in Conditions I and II would be expected to provide (a) sources of interference which would produce stimulus errors and (b) sources of

interference which would produce generalized response errors later in training as the weak-pair associative connection becomes stronger. With respect to learning the weak pairs, the inter-stimulus associative connections of Conditions I and II should serve as sources for stimulus errors and generalized response errors. On the other hand, the inter-word-pair S-R connections of Conditions I and III would be expected to serve as sources for response errors. Therefore, as far as the frequency and type of error are concerned, performance would be expected to vary among the three conditions.

Specifically, when Conditions I and II are compared to Condition III, the former should produce more stimulus errors on both the strong and weak S-R pairs and they should produce more generalized response errors on the strong

TABLE II
WORD PAIRS FOR EACH CONDITION OF THE McCULLERS EXPERIMENT

Stimulus			
Cond. I	Cond. II	Cond. III	Response
*Long	*Long	*Long	Short
Tall	Big	Little	Broken
*Hot	*Hot	*Hot	Cold
Warm	Boiling	Freezing	Funny
*Light	*Light	*Light	Dark
Bright	Sun	Black	Real
*Pretty	*Pretty	*Pretty	Nice
Beautiful	Ugly	Good	Same

* Strong associative pairs.

S-R pairs. Conditions I and III, however, should produce more direct response errors on the weak S-R pairs than Condition II. Finally, Condition I should produce more direct response errors on the weak S-R pairs than Condition III, since the association between S_A and $S_{A'}$ in Condition I would maintain through generalization, the strength of the $S_{A'} \rightarrow R_A$ connection.

The word-pairs employed by McCullers were selected from the word association norms of Castaneda, Fahel, and Odom, described earlier, and are presented in Table II. Four sets of word pairs were used in each condition with each set consisting of a strong S-R pair and a weak pair immediately below. The associative strengths of the strong S-R pairs and various competitive connections were approximately 20%; weak pairs carried initial associative strengths of approximately 1%. The association between the words of different sets in each condition was initially low (approximately 1%).

The findings of McCullers' experiment, with sixth graders, based on correct anticipations, are presented in Fig. 4, while Fig. 5 presents them based on

the type of error. The several types of errors are: (a) errors of omission, in which the stimulus item did not elicit a response during the anticipation interval, (b) stimulus errors, in which one stimulus item elicited the other stimulus item in its set, (c) response or generalized errors, in which a stimulus item elicited the response item of the other pair in its set, and (d) random errors, in which the stimulus item elicited either a word of another set or a word not contained in the list.

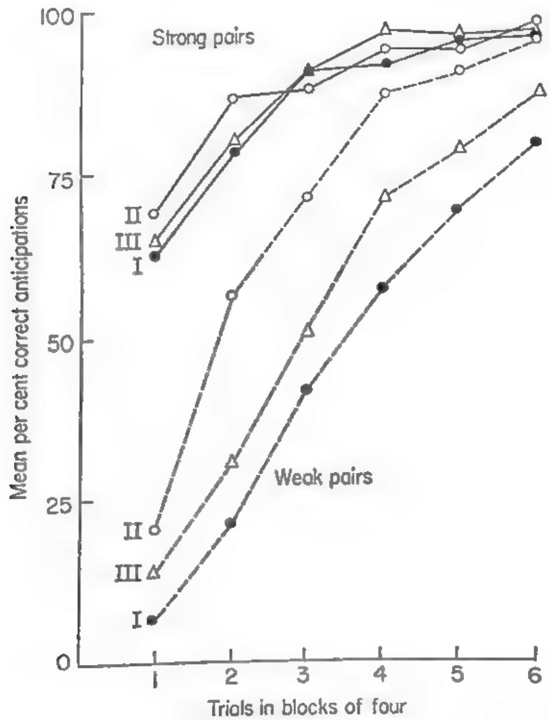

Fig. 4. Mean percentage of correct anticipations plotted separately for Conditions I, II, and III.

In general, McCullers' findings indicate that on the weak S-R pairs, Condition I, which had two sources of interference, resulted in reliably poorer performance than Conditions II and III, and that Condition I produced a statistically greater frequency of generalized response errors on the weak S-R pairs. Although it can be seen in Fig. 5 that relatively more generalized errors occurred on the strong S-R pairs in Condition I than Conditions II and III, this finding was not statistically reliable. McCullers suggested that this may have resulted from the fact that these S-R pairs were of such initially high associative strength that the effects of competition were obscured.

The results also indicated that the most effective single source of interference was that produced by the inter-word pair association. However, reliably more stimulus errors occurred on both weak and strong S-R pairs in Conditions I and II than in Condition III. Also, more generalized response errors occurred on the weak S-R pairs in Conditions I and III than in Condition II.

Thus, the results of the McCullers experiment indicate that associative connections between stimuli and those between stimuli and responses may function

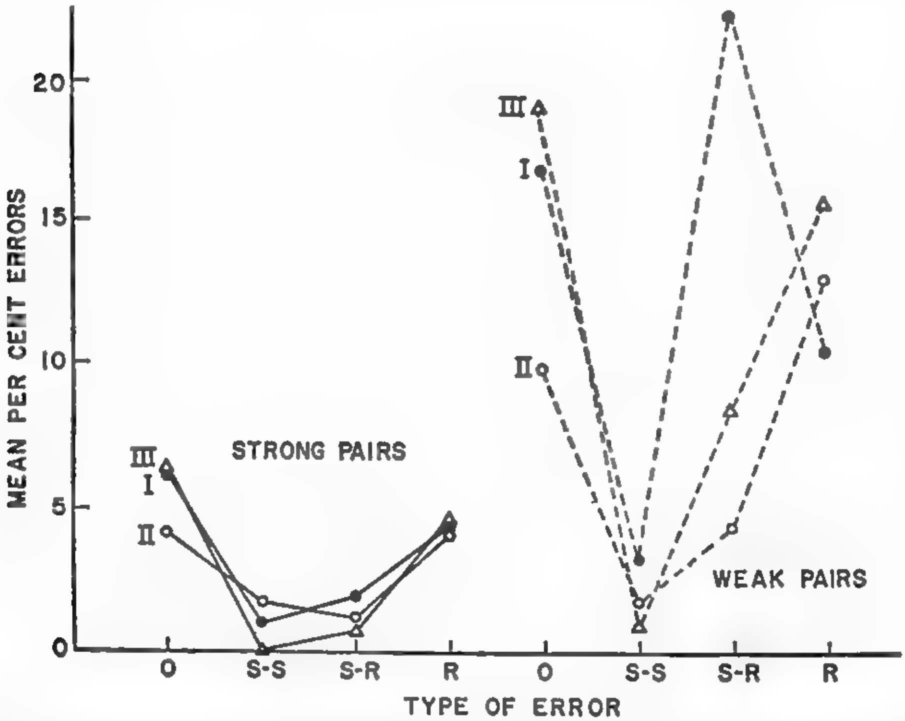

Fig. 5. Mean errors plotted separately for each type of error (see text for full explanation).

as sources of interference. Not only did each produce different numbers and types of errors, but each appeared to have a greater effect when these two error sources operated jointly, as in Condition I.

V. Sources of Nonassociative Transfer in the Within-*S*s Design

The findings of the McCullers study are consistent with the previous suggestion that the within-*S*s design needs to be analyzed to determine just which factors are operating. Furthermore, a closer examination of the within-*S*s de-

sign suggests the possibility that some of these factors may be motivational. For example, disregarding the hypothesized development of a generalized association between S_A and R_B, we may note several features about the stimulus $S_{A'}$, in Condition I as compared with its companion stimulus, S_A. First, there is the presence of competing or incompatible associations. At certain stages of training it is possible that the presentation of $S_{A'}$ to the *S* gives rise to a state of conflict due to the more or less simultaneous arousal of the competing tendencies. Secondly, the $S_{A'} \rightarrow R_B$ connection is initially weak in its associative strength. The effect of this latter factor, during the early stages of training, would be to cause the *S* to make errors, either overt errors or those of omission. The possibility exists, then, that the appearance of $S_{A'}$ gives

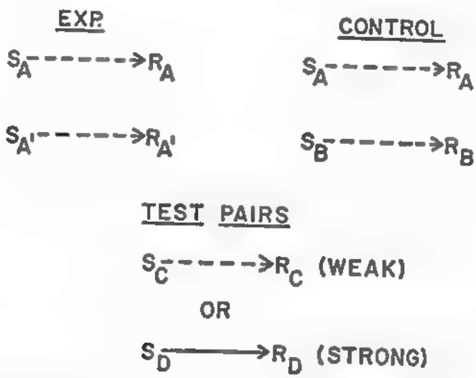

Fig. 6. Schematic representation of the to-be-learned S-R pairs in each condition.

rise to anticipations of responding incorrectly which, in turn, result in a state of apprehension on the part of the *S*. Because of the particular pattern of associative connections existing for this stimulus, then, *non*associative attributes such as *conflict* and *apprehension* may be generated.

Further examination of the paired-associates procedure in relation to the foregoing assumptions suggests some possible implications for performance. In view of the rather short temporal inter-pair intervals that are characteristic of the paired-associate experiment, it may be noted that the *S* is stimulated with S_A in close temporal contiguity with stimulation by $S_{A'}$. Assuming the hypothetical states of conflict and apprehension, aroused by $S_{A'}$, *persist* to that point in time when S_A is exposed, one must wonder whether the response is independent of these nonassociative or motivational states. Expressed otherwise, the question arises as to whether performance on S_A remains unaffected by these nonassociative states that may be generated by $S_{A'}$.

These considerations formed the basis for the next experiment (Castaneda & McCullers, 1962a), the basic features of which are presented in Fig. 6. The

two types of paired-associates lists used in this study are depicted in the figure under the headings, *experimental* and *control*. Six S-R pairs in sets of two were constructed in accordance with the diagram in the figure. Note that in the case of the experimental and control conditions, the S-R pairs are initially low in associative strength as indicated by the connecting arrows with broken shafts. Also, it may be noted that one of these S-R pairs, $S_A \rightarrow R_A$, is present in both conditions. The major difference is in the companion S-R pair in each set. In the experimental condition, the stimuli are selected for their high degree of similarity or synonymity, since our word association norms indicate that high associative connections exist between them. The response words in each set are also selected on this basis. In contrast, the inter-stimulus and inter-response associative connections in the control condition are kept at minimal strength.

By introducing strong inter-stimulus and inter-response associative connections into the experimental condition, the intent was to render performance on this portion of the list difficult relative to the corresponding portion in the control condition. Stated in terms of the preceding assumptions, the intent was to have the stimuli of the experimental list give rise to apprehension and conflict and to minimize these factors for the control condition. Recall that our interest concerns the possibility that these states may persist and affect responding to the other stimuli in the list which are presumed to be associatively unrelated. In an effort to achieve this condition, test pairs of one of two types are imbedded in the list, depicted in the diagram under the heading, *test pairs*. Both types, $S_C \dashrightarrow R_C$ and $S_D \rightarrow R_D$, are constructed so that neither the stimulus nor the response possesses any associative connection with either the stimuli or responses of the experimental or control conditions. The design of the experiment is such that half the *S*s in the experimental and control conditions have imbedded in their lists test pairs with initially weak associative connections ($S_C \dashrightarrow R_C$) while the remaining half of the *S*s in each condition have test pairs with initially strong associative connections between the items ($S_D \rightarrow R_D$). The experimental design permits assessment, then, of whether performance on the test pairs differs between the experimental and control conditions, and if the effect depends on the associative strength of the test pairs. A critical assumption is that the test pair members are not differently associated with those of the experimental and control pairs.

The pairs are exposed in a pattern that prevents their being learned serially. However, every alternate exposure is a test pair, and all pairs which are identical in both conditions are exposed on corresponding trials for both conditions.

The measure of principal interest is the number of trials to reach a criterion of one perfect recitation on the three *test* pairs. This is assumed to be the safer measure in that it is more likely to be independent of the number of

trials to reach the criterion on the experimental and control pairs than would be the number of correct anticipations or errors.

The mean number of trials to criterion are depicted in Fig. 7. It may be noted that when associative strengths of the test pairs are weak, the experimental group requires slightly more trials to reach criterion than the control group. On the other hand, this effect is reversed for test pairs with greater associative strengths. That is, the experimental group takes an average of approximately 5 trials to reach the criterion, whereas the control group requires approximately 7.5 trials. The interaction between conditions and type of test pair was found to be statistically reliable ($p < .025$). The difference between

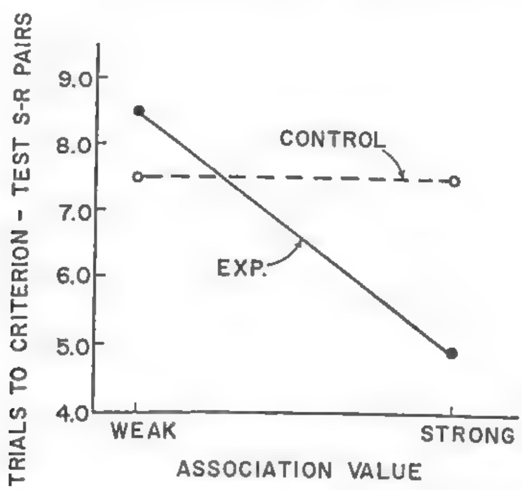

Fig. 7. Mean number of trials to reach criterion for the experimental and control groups on the test and control pairs.

experimental and control conditions on the test pairs mediated by initially strong associative connections was also found to be statistically reliable ($p < .01$), but fails to reach significance on test pairs mediated by a relatively weak associative connection.

If it is assumed that the stimuli of the experimental condition produce or generate states of apprehension or conflict, these results provide some evidence for their differential facilitating and interfering roles, depending on whether the associative connections of the test pairs are strong or weak. The results of this experiment could be intrepreted as consistent with Hull's (1943) assumption concerning the manner in which habit (associative) and motivational factors combine to produce response strength. Specifically, he assumed that response strength depends on all momentarily operative motivational factors combining indiscriminately with all existing habit tendencies that are

aroused by the stimulus situation. On the basis of Hull's assumption of a multiplicative function relating these two factors of habit and motivation, Spence (1956) derived a set of implications for performance in situations involving the presence of one or more competing response tendencies. For example, the effect of heightening the motivational level is expected to depend on the strength of the correct habit relative to other competing, incorrect habits which are present. Thus, if the strengths of the competing, incorrect habits are greater than the correct one, the effect of increasing the motivational level is expected to impair performance. If the correct habit is dominant, however, i.e., its strength is greater than the competing incorrect habit, the increase in motivational level is expected to facilitate performance. Corroborations of this set of hypotheses in studies with children have been reported elsewhere by the present writer and his associates (Castaneda, 1956, 1961; Castaneda & Lipsitt, 1959; Castaneda & Palermo, 1955; Castaneda, Palermo, & McCandless, 1956; Palermo, 1957).

In terms of the present experiment, interpretation of the interfering and facilitating effects found on the test pairs would require the assumptions that: (a) the experimental condition produced a heightened motivational level and (b) for weak test pairs, the correct association was in competition with relatively stronger competing associations, while the correct association was dominant in strength for test pairs mediated by initially strong associations. It is possible to use these assumptions to explain the learning of S-R pairs mediated by initially weak associative connections.[2] The explanation is based on the assumption that, even though intra-list sources of competition may be minimized, strong extra-list associations may be present, particularly when the verbal material is of the meaningful variety. This implies, for example, that forming an association between the words, *beautiful-warm,* would be impeded not only because the associative strength is initially weak but because of the competition from the strong, *extra*-list association, *beautiful-pretty,* as well.

These conclusions, however, should be qualified by one aspect of the present findings: the performance of the control conditions is practically identical on both the weak and the strong test pairs. In other words, no effect of associative strength was obtained for this condition. This finding may indicate that differences in associative strength have to be of greater magnitude in order to produce differences in performance in upper-elementary school age children. In the preceding studies the differences between weak and strong association values were greater, i.e., 1% versus 60–70%, respectively. In the present experiment the weak pairs consisted of associated items having association values of around 5% and the strong pairs, 20–30%. Word association norms based on child populations, as described in Palermo and Jenkins (1964), should be of

[2] The author is indebted to a former colleague, Janice Loeb, for the formulation of this explanation.

value in achieving associational patterns desirable for studies such as the present one.

VI. Special Methods

The next study to be described (Castaneda & McCullers, 1962b), which deals with essentially the same problem, also reflects the adaptability of the paired-associates method. This study is similarly concerned with the relation of conflict to performance in paired-associates learning, but employs somewhat different procedures.

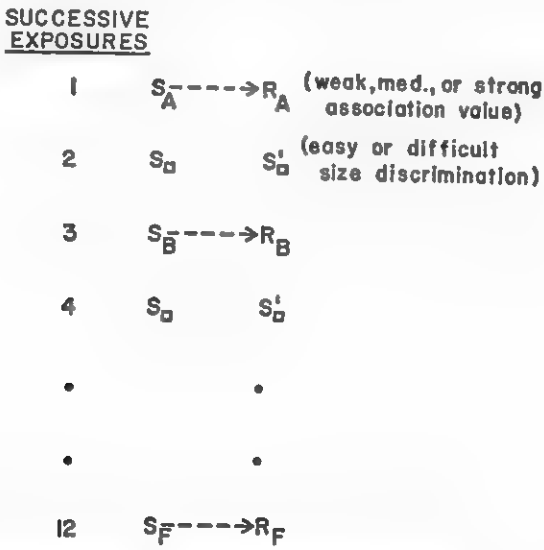

Fig. 8. Schematic representation of the experimental procedure (see text for detailed description).

The procedure involves exposing stimuli designed to arouse conflict on one exposure and assessing its effect on the subsequent exposure of a paired-associate item that is to be learned. The response which is required on the exposure involving the paired-associate item is different from and/or unrelated to that required during the exposure interval involving the conflict-producing stimuli.

Figure 8 depicts the basic characteristics of the experimental procedure. Note that in each condition there are six paired-associates which are mediated by weak, moderate, or strong association values. In the experiment, each trial consists of 12 exposures, every alternate one (exposures 1, 3, etc.) involving a paired-associate item. Every other exposure (exposures 2, 4, etc.), however, involves a size discrimination problem. Two squares are exposed in the memory

drum aperture, and the *S* is required to indicate the position of the *larger* square (right or left) by depressing one of two switches to signal his choice to the *E*. The size discrimination, depending on the condition, is increased in difficulty by reducing differences in size. In the case of the difficult discrimination, the difference is literally not detectable in the time permitted the *S* to make his choice. The stimuli are presented by the paired-associates procedure, i.e., first one square is exposed in the left window of the aperture for a 2-sec interval followed by a 2-sec simultaneous exposure with the companion square in the right window. Thus, the *S* has only 2 sec in which to make his selection. Differences in the size of the squares under the *easy* condition are immediately and readily detectable. The consequences of responding to the squares are nondifferential, i.e., the *S* is never informed as to the accuracy of his selection.

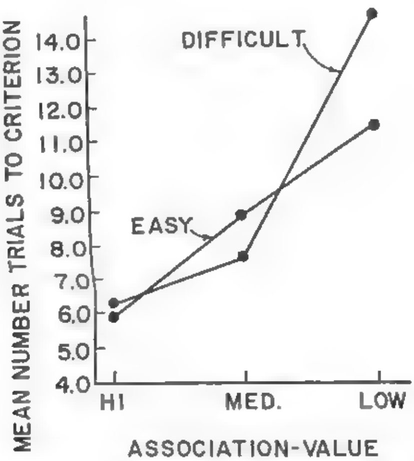

Fig. 9. Mean number of trials to reach criterion for each level of discrimination difficulty and association-value.

The experiment follows the factorial plan (2 × 3) involving two levels of conflict and three levels of associative strength. The *S*s were carried to a criterion of one perfect recitation on the paired-associates or to a maximum of 15 trials.

Figure 9 presents the results based on the mean number of trials to reach the criterion of one errorless trial, and they are plotted separately for the easy and difficult discriminations as well as for different strengths of association value. It may be noted that there was a tendency, in both the easy and difficult discrimination conditions, for trials-to-criterion to increase as association-value decreases. The effect of conflict, however, appears to vary as a function of association value. Note that there is a small difference in favor of the difficult condition on the medium strength pairs and a large difference in favor of the easy discrimination condition on the weak S-R pairs.

Analysis of variance revealed a significant interaction between conflict and association value ($p < .05$), which becomes slightly more reliable ($p < .025$) when the analysis is based on the easy and difficult conditions involving only the medium and low association value S-R pairs. Since the criterion is reached so quickly on the high association value pairs, this latter analysis was performed on the assumption that the associative strength was too nearly asymptotic and hence less susceptible to variations in conflict. The difference on the weak S-R pairs barely reaches statistical significance ($p < .05$). With the exception of this latter condition, the results suggest that conflict produces either facilitation or interference depending on the associative characteristics of the paired associates. Similarly, the same general theoretical interpretation appears as applicable to these results as to those of the previous study.

It is of interest to note that the method devised in this study for assessing the role of conflict-produced motivation has also been developed for situations involving simple, instrumental motor reactions in children by Steigman (1961) and Jean Eddy (1959).

In conclusion, the experiments described in the preceding sections indicate that the within-*S*s design for producing associative transfer in psychological experiments is susceptible to analysis involving the theoretical notions of conflict and response competition. Moreover, such analysis has led to a number of fruitful deductions which we can hope have illuminated some mechanisms underlying children's behavior.

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TRANSFER OF STIMULUS PRETRAINING TO MOTOR PAIRED-ASSOCIATE AND DISCRIMINATION LEARNING TASKS

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[1] There are two people with whom the writer has shared ideas in this area for many years and who therefore have contributed a great deal to this paper. The first is Dorothy E. McAllister, who collaborated with the writer on a paper (McAllister & J. H. Cantor, 1962) containing much of the material discussed here. The second is Charles C. Spiker, whose articles, lectures, and discussions have clarified numerous issues and suggested many of the present ideas. The writer is also indebted to Gordon N. Cantor for an extremely helpful critical reading of the manuscript.

Joan H. Cantor

I. Introduction

The S-R psychologist frequently finds it necessary to include verbal mediation processes in explanations of human learning phenomena. This is not at all surprising since even casual observation indicates that verbal stimuli are extremely powerful determiners of many kinds of human behavior. Since so much verbal behavior is unobservable, it is hypothesized that the occurrence of implicit verbal responses produces accompanying internal stimulus states usually referred to as verbal response-produced cues. These verbal cues may in turn elicit other responses, either overt or covert, and are therefore said to act as mediators between external stimuli and responses. It is assumed that the internal stimuli and responses have the same general properties of all other stimuli and responses; i.e., they enter into the same kinds of lawful relationships.

There has been widespread interest in the past decade in studying the effects of various kinds of verbal pretraining on subsequent performance in motor paired-associate or discrimination learning tasks. Certain hypotheses have been presented concerning the role of verbal cues in mediating transfer in these situations, while other hypotheses suggest that part or perhaps all of the transfer can be explained in terms of perceptual orienting responses. Much of the more recent research in this area has been done with children, who seem to be particularly suitable subjects for studying verbal mediation in relatively simple situations.

The purpose of this chapter will be threefold: (1) to review some of the hypotheses concerning the role of both verbal and perceptual orienting responses in these transfer situations, including certain methodological problems associated with evaluating the hypotheses; (2) to describe in some detail the relevant experiments which have used children as subjects; and (3) to examine these findings in terms of the implications which can be drawn from them concerning the usefulness of the various hypotheses.

II. Stimulus Pretraining Paradigms

Although the number of possible paradigms for investigating the effects of verbal pretraining is very large, most of the research to date has been done with two or three specific designs. For this reason, there has been a tendency to associate particular hypotheses with specific paradigms, resulting in an apparent specificity in the hypotheses that is unwarranted. The position to be taken here is that each hypothesis can be examined with respect to any of a large number of specific paradigms, and that the predicted direction of the transfer (positive or negative) is determined jointly by the hypothesis and the particular type and arrangement of stimuli and responses. For example, the

"acquired distinctiveness of cues" (ADC) hypothesis has almost always been used to explain positive transfer, yet with a small change in the design, the ADC hypothesis would predict negative transfer. The same is true of "acquired equivalence of cues" (AEC), also called "mediated generalization." Before elaborating on this point, it will be helpful to describe a number of designs usually classified as stimulus pretraining paradigms.

Table I presents schematic diagrams of the types of stimuli and responses used in three paired-associate pretraining tasks in which verbal responses are associated with nonverbal stimuli. These types of pretraining have been referred to as relevant S(timulus) pretraining (McAllister, 1953), since the stimuli are the same ones used in a subsequently presented transfer task, whereas the responses required in the two tasks are different. In Table I, each pretraining task (P1, P2, P3) constitutes the initial phase in four different transfer designs (a, b, c, d). The resulting total of 12 transfer paradigms will form the basis for the description of hypotheses. Although the paradigms are presented using only two stimuli in order to simplify the discussion, in practice these experimental designs ordinarily include additional elements. The subscripts and primes taken together indicate the amount of similarity assumed to exist among both the stimuli and responses. In pretraining task P1 (common to designs 1a–1d), the stimuli (S_1 and S_1') are considered to be highly similar. The verbal responses (R_{V_1} and R_{V_2}) are dissimilar, as are the stimuli (S_1 and S_2) in pretraining task P2. It may be seen further that the verbal responses in P2 are identical, whereas in P3 the stimuli are dissimilar and the verbal responses are similar.

The effects of the pretraining are assessed in the two-stage designs using a paired-associate transfer task in which motor responses (referring in a general sense to nonverbal responses) are paired with the pretraining task stimuli. For each type of pretraining, one two-stage design (1a, 2a, 3a) requires distinctive motor responses in the transfer task,[2] and the second two-stage design (1b, 2b, 3b) requires identical motor responses. Each two-stage design has a corresponding three-stage design in which one of the stimulus-(motor) response pairs is learned in Phase 2 and the other pair constitutes the final transfer task (Phase 3). For example, the first pair ($S_1 \dashrightarrow R_{M_1}$) in the second phase of 1a is learned in Phase 2 of 1c and the other pair ($S_1' \dashrightarrow R_{M_2}$) is learned in Phase 3 of 1c. Certain assumptions will be made in the discussion

[2] Spiker (1963a) has pointed out that motor paired-associate transfer tasks (such as 1a, 2a, and 3a), in which the stimuli are presented singly, can be viewed as successive discrimination problems. Furthermore, traditional simultaneous discrimination learning problems can be substituted for these transfer tasks by presenting the two stimuli simultaneously on each trial and requiring the subject to learn to approach the one arbitrarily designated as correct. The hypotheses to be discussed also apply to the simultaneous discrimination task, and it may be helpful to think of one of the motor responses in the paired-associate task as an approach response to the "correct" stimulus and the other as an avoidance response to the "incorrect" stimulus.

of these designs: (1) stimuli designated as highly similar are nevertheless considered to be discriminable by the subject; (2) a certain amount of stimulus generalization[3] occurs between the dissimilar stimuli; (3) the motor responses required in the transfer phases are not incompatible with the verbal responses learned during pretraining, so that both may occur simultaneously in the transfer task; and (4) by the end of training in each phase, the S-R associations are well established and they are retained at this high level during the subsequent phases of the experiment. The entries in the last three columns in Table I will be explained in the later discussion of specific hypotheses.

Probably the most frequently studied paradigm has been 1a, the first two-stage design in Table I. Experiments using this paradigm have usually been referred to as studies of "acquired distinctiveness of cues" or "stimulus predifferentiation." In this design, distinctive verbal responses are learned to similar stimuli during pretraining, and the prediction is made that the subsequent learning of distinctive motor responses to the same stimuli will be facilitated as a result of the pretraining. The major hypotheses will be described in detail in terms of this paradigm, and their implications with reference to the other designs will then be discussed.

III. Hypotheses Concerning the Effects of Stimulus Pretraining

A. Role of Verbal Cues

1. *Decreased Generalization*

The hypothesis of acquired distinctiveness of cues (Miller & Dollard, 1941) has been one of the most widely used explanations of stimulus pretraining effects. Miller (1948, p. 174) states what is essentially an application of learning principles and Hull's (1930, 1939) notion of response-produced cues:

> According to stimulus-response theory, learning to respond with highly distinctive names to similar stimulus situations should tend to lessen the generalization of other responses from one of these situations to another since the stimuli produced by responding with the distinctive names will tend to increase the differences in the stimulus patterns of the two situations. Increased differentiation based on this mechanism has been called acquired distinctiveness of cues.

[3] In the present paper, use of the concept of stimulus generalization is not restricted to situations in which the stimuli vary in similarity along a single physical dimension. Rather, the concept will be used in a more general sense to include situations involving multidimensional stimuli and stimulus complexes varying in number of common elements.

Schematizations of this hypothesis in S-R notation have been presented by Spiker (1953, 1963a) and Goss (1955), and a similar representation using paradigm 1a is shown in Fig. 1. During pretraining the subject learns distinctive verbal labels, R_{V_1} and R_{V_2}, for highly similar stimuli, S_1 and S_1' (e.g., lights, nonsense figures, tones). It is assumed in Fig. 1 that an implicit verbal response (r_V) as well as the overt verbal response (R_V) is learned to each stimulus; i.e., the subject "thinks" the correct response as well as saying it aloud. Furthermore, each implicit verbal response has a response-produced cue (s_V) associated with it, and it is these cues that are hypothesized to be responsible for the reduction in generalization in the transfer task. Whether r_V occurs prior to R_V is not a question of importance here. The arrow connecting

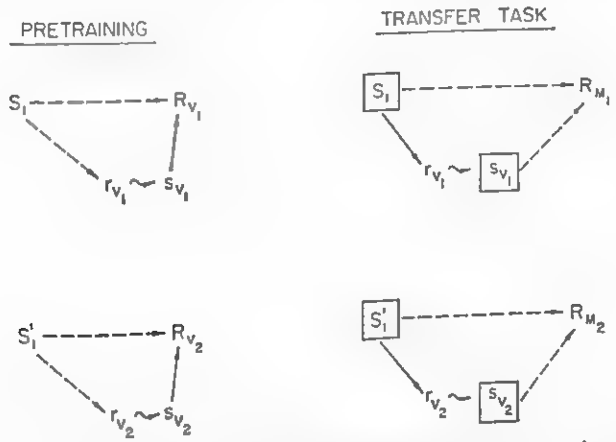

Fig. 1. S-R schematization of the acquired distinctiveness of cues hypothesis applied to paradigm 1a.

s_V with R_V merely suggests that, under the proper instructional set, the subject who "thinks" the correct response will say it aloud. Note that the dotted-line arrows represent associations to be learned in the task, whereas solid-line arrows designate connections that are well established at the beginning of the task.

In the transfer task, the subject is required to learn new responses (e.g., pushing buttons) to the same external stimuli used in the pretraining. It is assumed that each external stimulus elicits an implicit verbal response whose accompanying response-produced cue becomes part of the stimulus complex ($S + s_V$). Since the verbal cues are presumably more distinctive than the external stimuli in this design, generalization between the stimulus complexes should be reduced, resulting in facilitation of transfer task performance. It was noted earlier that the prediction that this type of stimulus pretraining will result in positive rather than negative transfer is determined by the nature of the particular transfer task. If the transfer task required that the same rather than

a different motor response be made to each stimulus (as in design 1b), the hypothesized reduction in generalization should interfere with performance on the transfer task.

The question might be raised as to whether a task requiring the same motor response to both stimuli is a learning task at all, since the subject could simply instruct himself to make this response consistently, with the result that specific S-R_M associations might not be established. This appears to be a methodological problem that might be eliminated by making certain changes in the design, e.g., requiring that a second motor response be made to each member of an additional pair of similar stimuli. The theoretical considerations in such a design, though perhaps more complex, would be essentially the same as those in 1b. In order to avoid becoming bogged down in the complexities of such expanded designs, it will be assumed here that the specified S-R connections are learned in all the designs.

Similar predictions in terms of reduced generalization would be made for the three-stage designs 1c and 1d in Table I. In 1c, a motor response is learned to

TABLE I

VERBAL PRETRAINING PARADIGMS

Verbal pretraining	Two-stage designs	Three-stage designs		Observing responses	Verbal responses	Verbal responses
Phase 1	Phase 2	Phase 2	Phase 3	Generalization	Generalization	Rehearsal
P1(a–d)	1a	1c				
$S_1 \dashrightarrow R_{V_1}$	$S_1 \dashrightarrow R_{M_1}$	$S_1 \dashrightarrow R_{M_1}$	$S_1' \dashrightarrow R_{M_2}$	+	+	+
$S_1' \dashrightarrow R_{V_2}$	$S_1' \dashrightarrow R_{M_2}$					
	1b	1d				
	$S_1 \dashrightarrow R_M$	$S_1 \dashrightarrow R_M$	$S_1' \dashrightarrow R_M$	−	−	+
	$S_1' \dashrightarrow R_M$					
P2(a–d)	2a	2c				
$S_1 \dashrightarrow R_V$	$S_1 \dashrightarrow R_{M_1}$	$S_1 \dashrightarrow R_{M_1}$	$S_2 \dashrightarrow R_{M_2}$	−	−	−
$S_2 \dashrightarrow R_V$	$S_2 \dashrightarrow R_{M_2}$					
	2b	2d				
	$S_1 \dashrightarrow R_M$	$S_1 \dashrightarrow R_M$	$S_2 \dashrightarrow R_M$	+	+	+
	$S_2 \dashrightarrow R_M$					
P3(a–d)	3a	3c				
$S_1 \dashrightarrow R_{V_1}$	$S_1 \dashrightarrow R_{M_1}$	$S_1 \dashrightarrow R_{M_1}$	$S_2 \dashrightarrow R_{M_2}$	+	+	+
$S_2 \dashrightarrow R_{V_1}'$	$S_2 \dashrightarrow R_{M_2}$					
	3b	3d				
	$S_1 \dashrightarrow R_M$	$S_1 \dashrightarrow R_M$	$S_2 \dashrightarrow R_M$	−	−	+
	$S_2 \dashrightarrow R_M$					

one of the stimuli in the second phase and a different motor response is required when the other stimulus is presented in the third task. In paradigm 1d, the same response is required in both phases. Assuming that the verbal cues learned during pretraining transfer to the later tasks, there should be a reduced tendency to generalize the response learned in Phase 2 to Phase 3.[4] The result should therefore be facilitation of Phase 3 performance in 1c and interference in 1d.

The hypothesis of "stimulus predifferentiation," often equated with acquired distinctiveness of cues, is found in E. J. Gibson's (1940) analysis of generalization and differentiation effects in verbal learning and was later applied to paradigm 1a by Gagne and Baker (1950). Gibson proposed that when stimulus items become differentiated in paired-associate learning, the resulting decrease in stimulus generalization will transfer to a new situation in which different responses are learned to the same stimuli. The reduced generalization among the stimuli is presumably the result of differential reinforcement of the responses during pretraining, but unlike the ADC hypothesis, no reference is made to the role of verbal cues as mediators of the transfer effect. Although no specific transfer mechanism was originally proposed in connection with stimulus predifferentiation, J. J. Gibson and E. J. Gibson (1955) later suggested that we learn to discriminate stimuli by "responding to variables of physical stimulation not previously responded to." These "identifying responses," which result in decreased stimulus generalization, seem to be essentially the same as "observing responses," and their possible role in the stimulus pretraining paradigms will be discussed in Section III, B, 1.

2. *Increased Generalization*

Miller and Dollard (1941) also assume that generalization can be increased as a result of stimulus pretraining. The hypothesis of acquired equivalence of cues is stated by Miller (1948, p. 174):

> . . . if the individual learns to respond to two quite different situations with the same verbal response, the stimuli produced by this response will be a common element mediating an increased amount of generalization from one situation to the other. This has been called acquired equivalence of cues, or secondary generalization.

[4] Predictions of reduced generalization in the three-stage designs cannot be made in terms of simple summation of associative tendencies established to the separate components of the stimulus complexes. These predictions can be made, however, under either of the following assumptions: (1) component associative tendencies are summated according to a principle such as the hypothesis of stimulus interaction described by Spiker (1963b); or (2) a single associative tendency is built up to the stimulus complex taken as a whole, and the similarity of stimulus complexes is decreased by the addition of distinctive elements.

The AEC hypothesis may be applied to the second set of four paradigms (2a–2d) in Table I although it has most often been identified with 2d. According to an analysis of paradigm 2a comparable to that previously applied to 1a, learning the same verbal response for both stimuli in pretraining should provide for the addition of identical verbal cues to the stimulus complexes in the transfer task, resulting in increased generalization and hence interference with the learning of the differential motor responses. In paradigm 2b, the increased similarity of the stimulus complexes should be facilitating. The same hypothesis of increased generalization among the stimulus complexes in the three-stage paradigms leads to predictions of negative transfer in the final task in 2c and positive transfer in 2d.

There is an additional consideration, however, that can be seen in an analysis of paradigm 2d shown in Fig. 2. During pretraining the same im-

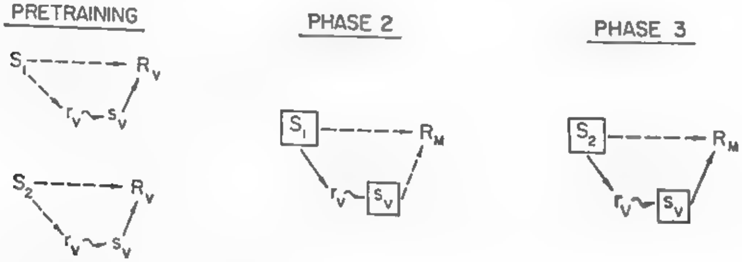

Fig. 2. S-R schematization of the acquired equivalence of cues hypothesis applied to paradigm 2d.

plicit verbal response, r_V, becomes associated with S_1 and S_2. In the second phase, r_V is presumably elicited by S_1, and an association is established between the verbal cue, s_V, and the motor response. In Phase 3, the motor response can be elicited *on the first trial* because of the previously established connections, $S_2 \rightarrow r_V$ and $s_V \rightarrow R_M$. The existence of the association between the verbal cue and the correct motor response at the outset of the final phase is a unique feature of paradigm 2d, and most studies of pretraining with identical verbal responses have used this paradigm. It is probably because the stimuli in Phase 2 and Phase 3 elicit the same motor response that the hypothesis used to explain the increased generalization has been called "acquired *equivalence* of cues." The stimulus complexes, $S_1 + s_V$ and $S_2 + s_V$, are not really equivalent in the sense of being identical; rather they are said to be equivalent because they elicit the same motor response, R_M. This apparent equivalence of these stimulus complexes, however, is due to the association built up between s_V and R_M in Phase 2 of paradigm 2d. The same association could lead to negative, rather than positive, transfer if a different motor response is required in Phase 3, as is true for paradigm 2c. It is confusing to refer to stimulus com-

plexes as equivalent when one intends to emphasize the *similarity* that results from a common response-produced component. These considerations suggest that the explanatory hypothesis might more appropriately be called the acquired *similarity* of cues. This terminology would also be more analogous to that of the properly designated hypothesis of "acquired *distinctiveness* of cues."

A summary of the predictions made for the paradigms discussed so far is presented in the column labeled "Generalization" (under "Verbal responses") at the right side of Table I. The plus and minus signs indicate the predicted direction of the transfer, and these predictions are the same for the two-stage and three-stage designs in each row in the table.

Before going on to the four paradigms involving pretraining task P3, two other hypotheses will be presented and examined with reference to the first two types of pretraining (P1 and P2). The discussion of the third type of pretraining will be delayed until all three hypotheses have been presented, since the position will be taken that, under the assumptions made in Section II, P3 can be analyzed as a special case of P1.

3. *Rehearsal*

Spiker (1956a, 1963a) has proposed an hypothesis concerning an alternative or additional role that verbal cues may play in producing transfer. It may be that if the subject has readily available names for the stimuli *during the transfer task,* he can spend the time between stimulus presentations and between trials rehearsing the correct associations. This would require that the subject also be able to represent the motor responses verbally or be able to orient toward the location where the particular response is made. For example, he might rehearse by saying to himself "Nij goes with button 2" or by simply looking at the particular button and giving it the name "Nij." In paradigm 1a diagrammed in Fig. 1, the effect of this rehearsal would be to strengthen the connections $s_{V_1} \dashrightarrow r_{M_1}$ and $s_{V_2} \dashrightarrow r_{M_2}$, where r_M is an implicit motor response or representation of the motor response that readily elicits the overt motor response during an actual trial. Facilitation would be predicted in this paradigm, and similarly, such rehearsal during Phase 3 in 1c should produce positive transfer.

It will be recalled that in paradigms 1b and 1d, the prediction was that decreased generalization should produce negative transfer. However, to the extent that the verbal cues are used for rehearsal, $s_{V_1} \dashrightarrow r_M$ and $s_{V_2} \dashrightarrow r_M$ should be strengthened, resulting in improved performance. For paradigms 2a–2d, the predicted effects of rehearsal are in the same direction as those based on increased generalization. Having the same name assigned to both stimuli might completely discourage any tendency to rehearse in transfer task 2a. To the extent that rehearsal did occur in this task, the associations $s_V \dashrightarrow r_{M_1}$ and $s_V \dashrightarrow r_{M_2}$

would both be strengthened. The resulting simultaneous arousal of both r_{M_1} and r_{M_2} on each trial should produce interference. Similarly in paradigm 2c, if the $s_V \dashrightarrow r_{M_1}$ connection is strengthened by rehearsal in Phase 2, the increased tendency to rehearse this incorrect association in Phase 3 should be interfering. The same sort of reasoning with reference to paradigms 2b and 2d leads to the prediction of positive transfer since the same motor response is required for both S_1 and S_2 in these instances. The various predictions for the rehearsal hypothesis are summarized in the third column on the right side of Table I.

B. Role of Observing Responses

1. *Decreased Generalization*

Learning theorists interested in discrimination learning in animals have suggested that certain attention responses, receptor-orienting acts, or observing responses may be required before the animal will be exposed to the differential aspects of the stimuli (Spence, 1940; Wyckoff, 1952). A more generalized formulation of observing responses has been suggested as an explanation of transfer in stimulus pretraining situations. Although Miller and Dollard (1941), J. J. Gibson and E. J. Gibson (1955), and Hake and Eriksen (1955) have discussed similar notions, Kurtz (1955) is primarily responsible for emphasizing the importance of observing responses in explaining transfer in paradigm 1a. Exactly what types of responses one would identify as observing responses is not entirely clear, but the essential notion is contained in Kurtz's (1955, p. 290) definition of an observing response as one ". . . which, when made to one or the other of a given pair of stimulus complexes which are different, consistently results in distinctive stimulation from those two stimulus complexes." Receptor-orienting acts certainly qualify, and so also do response sets that direct the subject's attention to certain specific properties or dimensions of the stimuli. Counting is also considered to be a response that results in distinctive stimulation. Although some of these observing responses may actually be implicit verbal responses such as "look for size differences," the hypothesized effect is not dependent on the transfer of verbal cues, but on the resulting increased discriminability of the external stimuli. Kurtz (1955, p. 290) gives such an interpretation of the facilitation found in an experiment using paradigm 1a:

> It is assumed that in the first task observing responses were learned which facilitated the association of differential verbal responses to the stimuli in that task, and that the same observing responses, not the verbal responses, were transferred to the second task and provided distinctive stimulation to which the motor responses in the second task were associated in turn.

A schematization of the role of observing responses and of their function in combination with verbal cues is shown in Fig. 3 in an analysis of paradigm 1a suggested by McAllister and J. H. Cantor (1962) and presented here in slightly modified form. Since the two external stimuli are highly similar, presumably the subject learns to make some sort of implicit observing response (r_0) to each stimulus, resulting in two changes in stimulation. First the observing response changes the effective external stimulus from S to $\tilde{S}$ by focusing attention on some discriminable aspect of the stimulus. For example, the subject may learn that two drawings of children's faces differ only in that one has straight hair and the other has wavy hair. The observing response (r_0) is

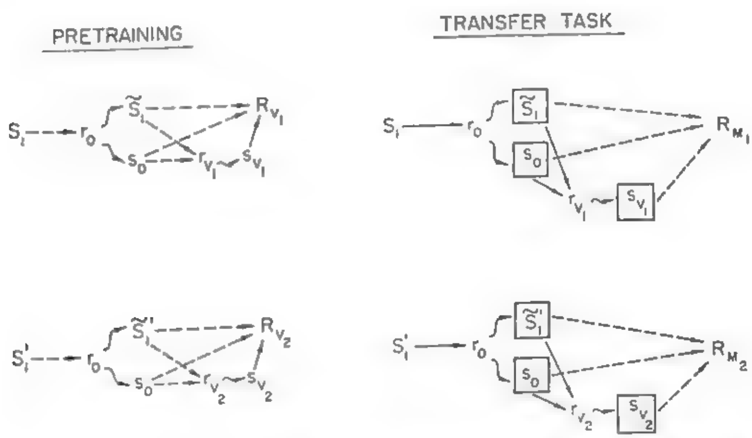

Fig. 3. S-R schematization of the combined role of verbal cues and observing responses in paradigm 1a.

orienting toward or looking at the hair. The effective stimuli are no longer the two highly similar faces (S_1 and S_1') but rather the straight hair ($\tilde{S}_1$) and wavy hair ($\tilde{S}_1'$), the latter being relatively discriminable stimuli. The observing response also produces its own cue (s_0), which may or may not be differential for the two external stimuli. In the above example, the observing response and its cue are considered to be the same for both faces. Similarly, if the two stimuli were geometric figures differing only in color, the self-instruction to pay attention to color would be the common observing response for both stimuli. In this case, the new effective stimuli would be the two colors. If, on the other hand, the stimuli were complex random shapes, the subject might learn to look for a particular jagged edge ($\tilde{S}_1$) in the upper right corner of S_1 and a specific contour ($\tilde{S}_1'$) in the lower left corner of S_1'. Again the new effective stimuli would be more discriminable than the original stimuli,

but in this case the observing responses of looking in the two corners would presumably have differential cues, s_{o_1} and s_{o_2}.

It would also be possible to construct stimuli that differ only in the location of a particular element, so that the subject could learn to make differential observing (orienting) responses, and yet the new effective stimuli would be identical. Therefore, it would seem necessary to examine the particular stimuli being used to determine how the observing responses might change the stimulus complexes. In many experiments using paradigm 1a, the same observing response is made to both stimuli, resulting in increased discriminability of the external stimuli, and this is the type of situation represented in Fig. 3. The implicit verbal responses presumably become associated with the new effective stimuli ($\tilde{S}_1$ and S_1') and also with the cue produced by the observing response. Assuming that the observing response and the verbal responses transfer to the second phase, the new stimulus complexes consist of $\tilde{S} + s_o + s_v$. The attention to the discriminable aspects of the stimuli is usually considered to be the most potent change produced by the observing response, and its net effect in paradigm 1a is assumed to be facilitating even though identical stimulus cues (s_o) have been added. In this paradigm, then, the learning of both the observing response and the verbal responses should produce positive transfer. Similarly, to the extent that the observing response reduces the generalization among the stimulus complexes, the predictions for paradigms 1b, 1c, and 1d would be the same as those based on the ADC hypothesis.

2. *Increased Generalization*

In pretraining task P2, it might be expected that the subject learns to look for similarities rather than differences in the external stimuli, since he is required to make the same verbal response to both stimuli. This would be particularly true in an expanded design including additional pairs of stimuli for which other names must be learned. In this case the new effective stimuli ($\tilde{S}_1$ and $\tilde{S}_2$) should be more alike than the original stimuli. If the subject does learn in this manner to look at the similar aspects of the stimuli, performance on the transfer task should be poorer in 2a and 2c and better in 2b and 2d. The predictions based on observing responses are summarized in Table I.

C. Verbal Response Similarity, Amount of Pretraining, and Their Interaction

Turning now to pretraining task P3, the question arises as to the effects of using similar verbal responses with dissimilar external stimuli. It would seem reasonable to assume that the addition of similar verbal cues increases the

generalization among the stimulus complexes in a manner similar to the addition of identical cues in P2. There has been a suggestion by Reese (1958), however, that the verbal responses in the pretraining task themselves undergo a process of differentiation that reduces the effective similarity of their cues. An analysis in terms of the two-stage verbal paired-associate learning process described by Underwood and Schulz (1960) may be helpful in clarifying this reasoning. They suggest that there is both a "response-learning" or "response-recall" stage and an "associative" or "hook-up" stage. In general, response learning precedes the associative stage, although there is probably a certain degree of overlap in the stages. Thus, in pretraining task P3, the subject must first learn to discriminate and recall the similar response words themselves before they can be associated with the external stimuli. The process which accomplishes this response learning may be similar to that which is hypothesized for pretraining task P1; i.e., the subject probably learns to make observing responses that orient him to the distinctive aspects of the response words and he may provide his own distinctive labels for the words. It therefore seems likely that by the time the pretraining task is mastered, the verbal cues are no longer functionally similar and that they serve both to reduce generalization and to facilitate rehearsal.

The observing responses learned to the external stimuli during pretraining should also tend to reduce generalization since the task requires differential responses and the subject would be looking for the discriminable aspects of the stimuli. If this analysis is correct, P3 may be considered to be a special case of P1 and the predictions concerning direction of transfer for paradigms 3a–3d would be the same as those in 1a–1d, although the amount of transfer would probably be less because the external stimuli are initially more distinctive in P3 than in P1. These predictions are summarized in Table I.

It will be recalled that one of the assumptions underlying all the discussion so far is that the verbal responses are well learned and that they are retained throughout the transfer task. When the amount of pretraining in P1 and P3 is insufficient to complete the associative stage in the pretraining task, there would be a tendency for intralist errors to occur during pretraining and to transfer to the later phases of learning. To the extent that both verbal responses are elicited by each stimulus, identical pairs of verbal cues are added to the stimulus complexes. Under these conditions, the predictions for P1 and P3 based on the role of the verbal cues are the same as for P2; i.e., negative transfer is predicted when differential motor responses are required and positive transfer when the same motor response is required for both stimuli. If the amount of pretraining is also insufficient to establish the observing response to the external stimuli, the predicted effects should be reduced, since the subject will not have learned to attend to the discriminable aspects of the stimuli in P1 and P3 or to their similar aspects in P2. It does not seem likely

that a reversal in the direction of transfer due to observing responses would occur for small amounts of pretraining.

Goss (1955) and Reese (1958) presented similar graphic portrayals of a set of hypothetical functions relating verbal response similarity and amount of pretraining to the amount and direction of transfer based on the role of verbal cues in changing generalization. Their analyses were specific to paradigms 1a and 3a (except that stimulus similarity was presumably considered to be held constant), but the essential ideas could be applied to the other paradigms as well. Curves similar to those presented by Goss and Reese are shown in Fig. 4. The amount and direction of transfer is plotted on the

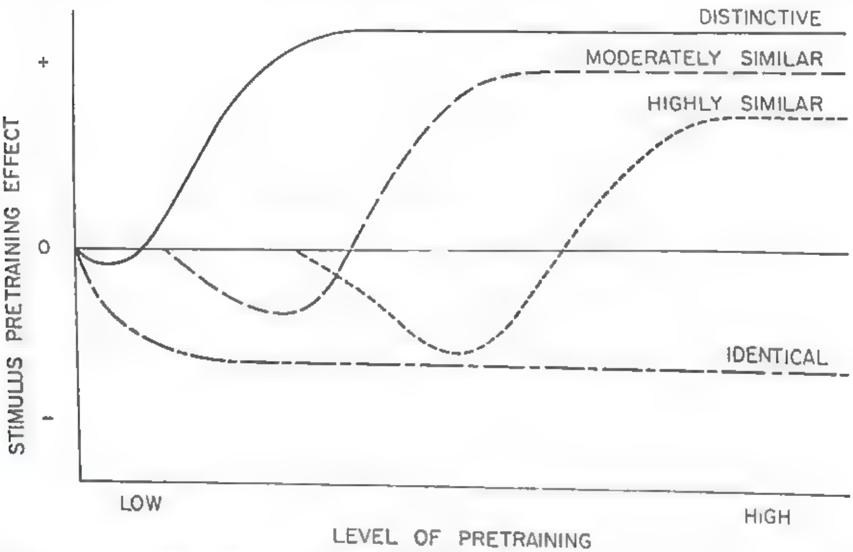

Fig. 4. Hypothetical functions relating verbal response similarity and amount of pretraining to the amount and direction of transfer in tasks requiring differential motor responses.

ordinate, with amount of pretraining being represented on the abscissa. The different curves represent different degrees of verbal response similarity. Stimulus similarity is held constant at some moderate level, allowing for changes in generalization in both directions. The transfer task is one requiring differential motor responses to the two stimuli. The curve for distinctive responses predicts slight negative transfer for small amounts of pretraining, with larger amounts of pretraining producing increasing amounts of positive transfer. As the response similarity is increased to moderate and high degrees, the initial amount of interference due to insufficient pretraining increases, as does the amount of pretraining required to begin producing facilitation. Furthermore, there are initial segments of the moderate and high similarity curves

showing no transfer effect, perhaps suggesting that the pretraining ended during the response-learning stage before any $S \dashrightarrow R_V$ associations had been established.

The suggestion that these functions asymptote at different levels is based on the assumption that the formal similarity of the verbal cues limits the amount of positive transfer, even though the cues themselves have undergone a process of differentiation. If, on the other hand, it were assumed that after the highly similar verbal cues become completely differentiated, they are as effective in reducing generalization as are the distinctive verbal cues, then the functions would presumably reach the same asymptote.

A curve has been added to those discussed by Reese and Goss to represent paradigm 2a in which identical verbal responses are learned. It will be recalled that negative transfer due to increased generalization was predicted for this paradigm, and the curve suggests that the amount of interference increases monotonically with amount of pretraining. There is no initial segment of zero transfer predicted for either the identical or the distinctive verbal responses since presumably there is little or no response learning required. Comparison of the curves for highly similar and identical responses shows that the process is conceived to be a discontinuous one. At the point where the verbal responses shift from being highly similar to functionally identical, the predictions of transfer effects change markedly and abruptly, particularly for large amounts of pretraining.

Before turning to another topic, it is probably worthwhile to point out again that these hypothetical functions are specifically concerned with generalization effects due to verbal cues, that they represent only one degree of stimulus similarity, and that they apply only to transfer tasks requiring differential motor responses. It would of course be possible to suggest functions for other hypotheses, variables, and paradigms.

IV. Control Conditions

Thus far, the discussion has centered on hypotheses concerning the transfer effects of relevant S pretraining, with no attention being given to the problems of assessing the direction and amount of transfer and of discriminating between the various hypotheses on the basis of their usefulness in explaining observed transfer effects. The whole issue of appropriate control conditions has been a complex one in this area for at least two reasons. First, there is often a tendency to designate certain types of controls as "correct" without also indicating the purpose for which they are correct. The question of what constitutes an adequate control cannot be separated from the specific interest of the investigator. Perhaps the most general question one might ask is whether

relevant S pretraining facilitates the learning of the transfer task in a paradigm such as 1a, with no concern for the possible sources of such facilitation. If such were the interest of the investigator, it would be appropriate to compare performance on the transfer task of a group given pretraining with that of a group given no pretraining. If the performance of the group given pretraining is superior, the conclusion that positive transfer has occurred is justified.

Usually, however, the investigator wishes to conclude something more specific about the source of the transfer, and this presents the second problem in connection with controls. For example, the purpose of a study may be to find out whether the transfer is due to the specific type of pretraining, to the experience with the stimuli, to the verbal cues, to observing responses, rehearsal, etc. Because of these specific interests, the problem of control conditions becomes more complicated and in some cases seems insurmountable. The present section will describe some of the controls used with relevant S pretraining, the purposes for which they are used, and the advantages and disadvantages of each.

In most instances the purpose of a study using relevant S pretraining is to investigate the role of one or more of the hypotheses discussed earlier, and therefore it is necessary to rule out nonspecific sources of transfer such as experience with the experimental situation, warm-up, and learning-to-learn. The performance of a control group given irrelevant pretraining (McAllister, 1953) is frequently compared with that of the relevant S group in order to control for such nonspecific sources of transfer. In the irrelevant paired-associate pretraining task, the stimuli are different from those in the transfer task, the verbal responses are the same as those learned in the relevant S pretraining, and the difficulty of the task is equated with that used for relevant S pretraining. Any difference in performance on the criterion task following the two types of pretraining can presumably be attributed to some aspect of the experience with the relevant stimuli. Whether such transfer effects are due to the role of observing responses or verbal responses cannot usually be determined.

The summary of the predictions in Table I shows that the verbal response and observing response hypotheses concerning changes in generalization both predict the same type of transfer for all of the paradigms. Since the irrelevant pretraining does not control for either of these effects, it is not helpful in separating their respective contributions to transfer. The same is true regarding the rehearsal hypothesis except in paradigms 1b, 1d, 3b, and 3d in which rehearsal should produce positive transfer in opposition to the negative transfer predicted under the other two hypotheses. If rehearsal is a very potent factor relative to the others, then evidence of facilitation should be found using an irrelevant pretraining control with these designs. If, on the other hand, rehearsal *and* one or both of the other factors are important, their effects should tend to cancel each other.

Another type of control called attention pretraining has been used in an attempt to study the effects of the verbal cues and the observing responses separately. In this type of pretraining, the relevant stimuli are presented and an opportunity is provided for the learning of observing responses in a task requiring, for example, that the subject point to particular parts of the stimuli or else respond "same" or "different" to pairs of stimuli. The subject can be given the set either to look for differences (control for P1 and P3) or to look for similarities (control for P2) among the stimuli. If this type of experience does adequately control for the learning of observing responses, then differences in performance following attention and relevant S pretraining could be attributed with more confidence to the effects of the verbal cues.

There are, however, a number of problems in using attention pretraining for this purpose. In those designs for which positive transfer is predicted, superiority of a relevant S group to an attention group could be attributed not only to the role of verbal cues, but also to learning-to-learn, since attention pretraining does not usually provide experience in learning a paired-associate task. This difficulty could perhaps be eliminated by giving both attention and irrelevant pretraining to the control group.

There may also be a question of whether the same kinds of observing responses are learned in relevant S and attention pretraining. The assumption is made that, during relevant S pretraining, the subject learns to make consistent observing responses. In making the judgment of "same" or "different" to pairs of stimuli, it may be that different aspects of the stimuli are attended to on different trials, and the relevant S pretraining might result in greater transfer because of the more consistent use of well-established observing responses. This problem would be less serious for stimuli that differ or are alike in only one respect. Also, the difficulty might be reduced considerably if the stimuli to be compared are presented successively rather than simultaneously.

These problems in interpretation occur when the attention pretraining results in less transfer than the relevant S pretraining. If, on the other hand, no difference is found between these two conditions, verbal cues cannot be eliminated as a possible source of transfer, since the subjects may have provided their own verbal labels for the stimuli during attention pretraining and thus produced their own relevant S pretraining.

The use of within-subjects designs is a fairly recent development that provides more sensitive tests of the predictions by reducing the error variance and also has other advantages in some cases. For example, if the subjects are pretrained on task P1, the control condition for paradigm 1a can be introduced on a within-subject basis by adding to the transfer task a pair of stimuli and motor responses that the subjects have never seen before. Any difference in performance in response to the relevant as compared with the new stimuli could not be attributed to nonspecific transfer. Similarly, if the same subjects were

given relevant S pretraining on one pair of stimuli and attention pretraining on a second pair, learning-to-learn would not have to be considered in comparing the effects of these two types of pretraining.

None of the control conditions devised so far seems adequate for the purpose of testing the hypotheses separately. Though it may not be possible to eliminate completely or control for the effects of one or more of these factors, experimental manipulation of certain variables may produce results that can be most reasonably explained in terms of a single hypothesis. For example, amount of transfer can be studied as a function of the length of the intertrial and interstimulus intervals and also as a function of instructions to rehearse during these intervals (Peters, 1963). Thus, while it may not be possible to prevent subjects from rehearsing during the criterion task, it may be instructive to manipulate the amount of rehearsal that occurs. It seems likely that these experimental manipulations would have relatively little effect upon the changes in generalization due to observing responses or verbal cues.

With respect to the possible effects of observing responses, it may be helpful to vary certain aspects of the stimuli. For example, one pair of stimuli might require that the same observing response be made to both members, while another pair would require different orienting responses to the two stimuli. If the cue function of observing responses is important, it should be possible to show differential transfer for the two pairs of stimuli.

There may also be ways of independently manipulating amount of change in generalization as a function of verbal cues. If, for example, there are data which suggest that the curves shown in Fig. 4 asymptote at different levels for similar and dissimilar verbal responses, it would seem most reasonable to explain the results in terms of the ADC hypothesis.

None of these interpretations of particular results would be entirely clear-cut, and it could be argued that alternative explanations are possible. Such problems in interpretation are not unique to the area of stimulus pretraining, however, and we must rely on evidence accumulated over a large number of related experiments to determine the utility of each of the specific hypotheses. There are not likely to be any "crucial" experiments.

V. Stimulus Pretraining Studies with Children

Before turning to the research with children, it may be worthwhile to give a clearer view of the scope of the discussion by first mentioning certain groups of pertinent studies that will not be described. The choice of literature to be reviewed has been based on the assumption that a fairly detailed description and discussion of a relatively small number of studies will be more useful to the reader than a more superficial treatment of a large number of experi-

ments. Therefore, no attempt will be made to summarize the results of the large number of stimulus pretraining experiments using adult subjects. Also excluded are groups of child studies in which the effects of stimulus pretraining are assessed in concept formation tasks, in transposition tasks, or in terms of stimulus preferences.[5] The remainder of the chapter, then, will be devoted primarily to a description of the studies done with children using one or more of the paradigms in Table I. The results of these experiments will be examined in an attempt to evaluate the various hypotheses previously discussed.

A. Paradigm 1A

In one of the earliest experiments with children, G. N. Cantor (1954, 1955) used a simultaneous discrimination criterion task to study the effects of relevant S, irrelevant, and attention pretraining. The relevant stimuli were two simple line drawings of similar girls' faces. Probably the most obvious differences were in the hair, but the eyes and mouths could also be distinguished. Boys' faces comparable in number of distinguishable features and over-all similarity were used as irrelevant stimuli. Subjects in the relevant group learned the names *Jean* and *Peg* for the faces, and those in the irrelevant group learned the names *Jack* and *Pete*. The pictures were presented simultaneously on each trial, and pretraining was continued until both correct names were given on 15 consecutive trials. The subjects in the attention group were also presented with the girls' faces, but they were only required to point to a particular feature (hair, eyes, etc.) on each of 30 trials. The children in all groups were rewarded for correct responses with coins that were cashed in at the end of pretraining for half a toy set. During the transfer task, all groups were given the same simultaneous discrimination problem with the girls' faces as stimuli, one being arbitrarily designated as correct. The pictures were attached to wooden cars, and the subject's task on each of 30 trials was to choose the correct car to roll down a grooved track. Correct responses were rewarded with marbles that were later exchanged for the rest of the toy set. The subjects were 60 preschool children assigned to two age levels and divided equally among the three groups.

None of the effects involving age level was significant for either pretraining or transfer performance. The analyses indicated that the relevant and irrelevant groups did not differ reliably in number of trials through the pretraining criterion, their respective means being 27.4 and 24.6. In terms of total correct responses on the 30 transfer task trials, the relevant group ($\bar{X} = 22.2$) was

[5] Spiker (1956b) has summarized the results of studies of the latter two types and has also analyzed human transposition behavior in terms of the ADC and AEC hypotheses.

superior to both the attention group ($\bar{X} = 17.7$) and the irrelevant group ($\bar{X} = 16.8$); the difference between the control groups was not significant. This clear evidence of facilitation in the relevant group is consistent with both the ADC and rehearsal hypotheses. The finding that the attention group did not differ from the irrelevant group suggests that specific observing responses to the relevant stimuli did not play an important role. On the other hand, it could be argued that any advantage the attention group might have had due to observing responses may have been nullified by learning-to-learn in the irrelevant group, although the assumption that a paired-associate task provides learning-to-learn for a simultaneous discrimination task seems rather tenuous. Another explanation of the comparability of these two groups seems more plausible. The boys' faces differed in the same features (hair, eyes, mouths) as did the girls' faces, and perhaps what both of these groups learned during pretraining was an observing response of attending to these relevant features. Although the observing responses made in the relevant group may have been more consistent (e.g., always paying attention to the hair), the clear superiority of this group would seem to be best explained in terms of the verbal cues.

In a study similar in many respects to the G. N. Cantor (1955) experiment, Norcross and Spiker (1957) gave relevant S, attention, or irrelevant pretraining to 70 preschool children divided into two age levels. The stimuli (faces) and verbal responses (names) were the same ones used by G. N. Cantor and were assigned in the same way to the three groups. The pretraining procedures were somewhat different. For all groups, each block of four pretraining trials contained one trial in which two identical pictures of one of the faces were presented simultaneously, one trial in which identical pictures of the other face were presented, and two trials in which the pair consisted of one picture of each face. Subjects in the relevant and irrelevant groups learned to say the appropriate name for each picture, and those in the attention group learned to say "same" when the pictures were identical and "different" when both faces appeared together. Verbal reinforcement or correction was used on each trial. The pretraining criterion was 12 consecutive correct trials, and subjects who did not meet this criterion within 60 trials were eliminated from the experiment. In the transfer task, each girl's face was attached to the front surface of a wooden box. One of the stimuli was arbitrarily designated as correct, and both boxes were presented on each of 30 trials. If the child picked the correct box on a given trial, he found a marble underneath; when an error was made, the experimenter pointed to the correct box. The marbles were later cashed in for a toy.

There were no significant group or age level differences in number of trials to the pretraining criterion. The means of total correct responses over the 30 transfer task trials (age levels combined) for the relevant, irrelevant, and attention groups were 22.15, 19.15, and 18.16. The groups differed sig-

nificantly, as did the age levels, but the interaction was not significant. Follow-up comparisons indicated that the relevant group was superior to both of the other groups, but the irrelevant and attention groups did not differ. The results are therefore essentially the same as those found by G. N. Cantor and can be interpreted similarly with respect to the hypotheses. Although the possible role of observing responses cannot be ruled out, it seems likely that the verbal cues contributed to the superior performance of the relevant group either through ADC, rehearsal, or both.

In order to strengthen further the control for observing responses, Spiker and Norcross (1962) provided attention pretraining in which the same-different judgments had to be made to the stimulus pairs on a successive as well as a simultaneous basis. This attention group was compared with a relevant S group and with an attention group given only the simultaneous comparisons of the stimuli. The subjects were 51 preschool children equally divided among the three groups. The stimuli were the girls' faces (G. N. Cantor, 1955). The pretraining procedures and criterion were the same as those used by Norcross and Spiker (1957) for the relevant and simultaneous attention groups, with the following exception: each attention group subject who met the criterion was continued until the total number of trials equaled that of a matched subject in the relevant group. Subjects in the successive attention group first learned the same-different responses to the simultaneously presented stimuli, and after 12 consecutive correct responses, they were switched to a successive presentation procedure (1–2 sec per picture) and again brought to the same criterion. Each of these subjects was also given the same total number of trials as a matched subject in the relevant group. The apparatus and procedures in the transfer task were identical to those used in the Norcross and Spiker study.

Although the errors to criterion suggested that the relevant task was more difficult than either of the attention pretraining tasks, the total number of pretraining trials was the same for all groups, due to the matching procedure. The means of total number of correct responses in 30 transfer task trials for the relevant, simultaneous attention, and successive attention groups were 25.9, 23.9, and 23.0. The learning curves for the three groups did not start separating until the last 20 trials, and the groups $\times$ trials interaction was significant. Tests of the group differences for individual five-trial blocks indicated that the relevant group was superior to both attention groups toward the end of training. There was no indication that the successive attention pretraining produced better transfer task performance than did the simultaneous procedure. The consistency of results for the three experiments discussed thus far provides rather convincing evidence for the importance of the verbal cues in these situations. An explanation of the results in terms of learning-to-learn or observing responses seems less plausible, particularly under the condi-

tions in the last experiment. There does not appear to be any basis for discriminating between the ADC and rehearsal hypotheses with reference to these studies.

Smith and Goss (1955) used preschool and kindergarten children ($N = 48$) to compare the performances of a relevant S group, two attention groups, and a no pretraining group. The stimuli were four white squares differing in area. During relevant pretraining, the subjects learned to associate a different nonsense syllable (*dap, guz, ril, tek*) with each square. A criterion of seven out of eight correct responses was used; if this criterion was not met, pretraining was terminated at the end of 96 trials. Subjects in the "seeing-and-discriminating" attention group were told to look for differences in the stimuli and to "talk about" each one as it appeared. These instructions were designed to elicit verbalizations about size differences in the squares. The only instruction given to the "seeing" attention group was to watch the squares, with no mention being made of looking for differences. Each attention group subject was matched with a relevant group subject to determine the number of presentations. Forty trials were given on the motor task, in which the subjects learned to push one of four toggle switches to each of the squares.

The pretraining task was apparently very difficult for children of these ages, since only 2 of the 12 subjects in the relevant group met the verbal learning criterion within 96 trials. Analyses of the motor task performance indicated that the relevant group and the seeing-and-discriminating group were superior to the other control groups. The latter two groups did not differ; in fact, neither group performed above the level of chance. The relevant group made fewer errors than the seeing-and-discriminating group at the end of training.

These results are not readily interpretable because of the difficulty of the tasks used. The seeing-and-discriminating group was probably a modified relevant S group, since the instructions presumably resulted in the elicitation of verbal descriptions of the stimulus size differences. The poorer performance in this group compared with that of the relevant group at the end of training could be due to the relative ineffectiveness of the subject-supplied labels. On the other hand, it could be argued that there was differential learning-to-learn in these groups, or that there was more consistent use of observing responses in the relevant group. The fact that both these groups were superior to the other control groups can be viewed as being consistent with the ADC, rehearsal, or observing response hypotheses.

In an experiment reported by Reese (1961), transfer in paradigm 1a was studied as a function of level of pretraining, using 90 fourth- and fifth-grade children as subjects. The criterion task required button-pushing responses to two similar red lights and two similar green lights presented successively in a single aperture. The subjects learned nonsense names (*lev* and *wog*) for

one pair of colors during pretraining. Three levels of pretraining were used: the high criterion was 19 correct responses in 20 consecutive stimulus presentations (Group H); the moderate criterion was seven correct responses in ten consecutive presentations (Group M); and the low criterion was three consecutive correct responses (Group L). In the transfer task, one button was associated with the light-green and the dark-red lights, and a second button was associated with the light-red and the dark-green lights. All subjects received 18 transfer task trials, a trial consisting of one presentation of each of the four colors.

The mean numbers of presentations through criterion in the pretraining task for Groups L, M, and H were 6.1, 9.3, and 32.3. The transfer task data were analyzed in terms of total errors in six-trial blocks. A significant levels $\times$ conditions $\times$ trial blocks interaction was found, and comparisons on individual trial blocks indicated that there were fewer errors made to the relevant stimuli ($\bar{X} = 4.6$) than to the control stimuli ($\bar{X} = 5.5$) in the first trial block for the groups combined. Although the difference between the relevant and control condition means increased with increasing levels of pretraining in the first trial block, this interaction was not significant.

Because each subject served as his own control, the difference between the relevant and control conditions cannot be attributed to nonspecific sources of transfer. The difference could be explained in terms of either of the verbal response hypotheses; furthermore, since the control stimuli were not seen during pretraining, the positive transfer could also be attributed to observing responses learned to the relevant stimuli. The finding that facilitation occurred only in the first trial block might be explained by the fact that the motor task was apparently quite easy for the children; on the average, only four or five errors were made in 24 stimulus presentations even in the first trial block.

B. Paradigms 1a and 3a Combined

The experiments to be described in this section and in the subsequent section each combined two types of pretraining previously diagrammed in Table I. Since these experiments were not concerned with varying stimulus similarity, the same degree of similarity was used for both types of pretraining in each experiment.

In what was probably the first experiment comparing paradigms 1a and 3a, Gerjuoy (1953) used 76 second-, third-, and fourth-grade children to study the variables of verbal response similarity and overt versus nonovert verbalization during motor training. The relevant stimuli were three white lights differing in spatial location on a vertical panel, each light being associated with a dif-

ferent nonsense syllable during pretraining and a different button during the motor task. All subjects were given two experimental sessions 5 days apart, each session consisting of a pretraining task followed by a motor criterion task. In the first session, there were four relevant S groups representing the four treatment combinations: similar-overt, similar-nonovert, dissimilar-overt, and dissimilar-nonovert. During the second session, both conditions were changed for each group; i.e., the group having similar-overt first had dissimilar-nonovert second, etc. A fifth group used as a warm-up control had a color-naming pretraining task in both sessions. The procedures were the same in both sessions except that different sets of locations of the three lights were used to provide different learning tasks.

During verbal pretraining, the lights were presented, one at a time, and the subject learned either the similar responses (*dij, lij, nij*) or the dissimilar responses (*mup, kos, zal*) to a criterion of 18 consecutive correct responses. A set of five colored lights (two orange, two green, and one red) were used for the control subjects, who were required to name the color of the light shown in each of 42 presentations. All subjects learned the same motor task with the three white stimulus lights. A correct button-pushing response turned off the light, but no correction was allowed. Subjects in the overt verbalization condition were told to say the name of the light aloud before pushing a button. No mention was made of saying the names in the nonovert and control conditions. The criterion for the motor task was nine consecutive correct responses.

Analysis of the pretraining data suggested that the similar responses were more difficult to learn than the dissimilar responses, but this difference was significant at only the 10% level. The transfer task means of trials to criterion and errors to criterion are shown in Table II. In an analysis of trials to criterion for the four relevant groups, overt verbalization ($\overline{X} = 18.13$) was found to be superior to nonovert verbalization ($\overline{X} = 24.10$). No significant effects were found in a similar analysis of errors to criterion. Since the relevant groups did not differ on either measure, they were combined for purposes of comparison with the control group and were found to be superior in terms of both measures in the first session. There was a significant decrease in errors in the control group from the first to the second session.

The difference in performance between overt and nonovert verbalization lends support for the ADC and rehearsal hypotheses, which are dependent upon the occurrence of verbal cues. It might be argued instead that requiring the overt verbal response forces the subject to make the appropriate observing response, and the latter is responsible for the facilitation. However, it is difficult to see why the motor responses required in all groups would not be just as effective in ensuring the occurrence of the observing responses. Since the only differences among the stimuli were in spatial location, observing responses would presumably not change the effective external stimulus in this situation,

but rather would reduce generalization by adding differential kinesthetic cues associated with the specific orienting responses. The differences between the combined relevant groups and the control group could be attributed to these observing response-produced cues as well as to the verbal cues.

There is also the possibility that part of the difference was due to learning-to-learn, since the control group had no paired-associate pretraining. This is consistent with the finding that the control group was the only one showing significant improvement in motor performance from the first to the second session. However, the control group means, even in the second session, were inferior to the combined relevant means in the first session, suggesting that

TABLE II

Means of Trials to Criterion and Errors to Criterion in the Motor Task (Gerjuoy, 1953)

		Similar		Dissimilar			
		Overt	Nonovert	Overt	Nonovert	Total relevant S	Control
Trials to criterion	Session 1	14.53	27.53	21.66	22.40	21.53	42.47
	Session 2	12.87	28.27	23.47	18.20	20.70	32.53
Errors to criterion	Session 1	8.33	13.60	10.33	10.60	10.72	24.47
	Session 2	5.53	12.90	9.00	7.27	8.65	13.33

learning-to-learn does not account for all the facilitation in the relevant condition. Since a relatively high pretraining criterion was used, the finding that the similar and dissimilar verbal responses both produced positive transfer is consistent with the hypotheses discussed for paradigm 3a (see Section III, C). Although the data are consistent with such an ADC interpretation, they can be equally well handled by the observing response hypothesis.

Norcross (1957, 1958) studied amount of transfer in relation to verbal response similarity in an experiment with kindergarten children. A button-pushing criterion task was used, and the stimuli were two pairs of pen and ink drawings of Indian children's faces, one pair being boys and the other pair girls. Each subject learned similar nonsense names (*zim* and *zam*) for one pair of faces and dissimilar names (*wug* and *kos*) for the other pair. Two subgroups of 15 subjects each were used to counterbalance the assignment of similar and dissimilar names to the boys' and girls' faces. In the transfer task, all subjects learned to press a different button for each of the four faces. Two ex-

perimental sessions were used, the interval between sessions ranging from 1 to 3 days.

On Day 1, the children first became familiar with the four names and then learned to associate the names with the faces. The stimuli were presented, one at a time, with boys' and girls' faces alternating in successive presentations. Verbal reinforcement and correction were used, and when an error occurred, not only was the correct response given by the experimenter, but the picture associated with the incorrect response was also shown. The pretraining continued on Day 1 until a criterion of one correct trial was met; a trial in both pretraining and motor learning referred to the successive presentation of all four stimuli. Subjects who did not meet the criterion within 18 trials were eliminated.

On Day 2, the subjects were first brought back to the Day 1 criterion. In the transfer task, which followed immediately, the subject was told to name the picture out loud and then push the button associated with that picture. No correction was allowed. After each response, a small light next to the correct button came on to provide the reinforcement or correction. In addition, a bell was sounded immediately following each correct motor response. If the subject made a within-pair error in naming (i.e., confused the names of one sex) during the motor task, no correction was made. If, on the other hand, a between-pair naming error occurred, the experimenter indicated the two names appropriate for the pair of which the stimulus was a member. Fifteen transfer task trials (60 stimulus presentations) were given to all subjects.

The number of correct dissimilar responses on Day 1 did not differ significantly from the number of correct similar responses. On the transfer task, significantly more correct motor responses were made to the stimuli having dissimilar names ($\overline{X} = 20.20$) than to the stimuli having similar names ($\overline{X} = 16.90$), and this superiority was maintained throughout the 15 trials. However, it was also found that the number of incorrect similar verbal responses given during the transfer task was significantly greater than the number of incorrect dissimilar responses. Thus, the difference in motor task performance for the two conditions might be attributable to the relative inconsistency with which the similar verbal cues were elicited during the button-pushing task.

In order to attempt to eliminate this problem in interpretation, a second experiment was performed that differed from the first in only one respect: the subjects were corrected for incorrect verbal responses during the motor task and were required to say the correct name before pressing a button. Thirteen subjects were assigned to each of the two counterbalancing subgroups. The results of the second experiment were essentially the same as those in the first experiment. Significantly more correct responses were made to the stimuli having dissimilar names ($\overline{X} = 22.73$) than to those having similar names ($\overline{X} = 19.62$).

These two experiments provide rather convincing evidence that the verbal cues play a role in mediating transfer in these paradigms. The obtained difference between the similarity conditions cannot be explained in terms of observing responses, since the subjects were required to make differential responses to both pairs of faces, and presumably the observing responses learned to both pairs during pretraining transferred equally well to the motor task. Although the obtained difference is therefore best explained in terms of verbal cues, Norcross pointed out that the design does not permit a conclusion concerning the direction of the obtained transfer effect. The results of previous experiments clearly suggest that the learning of dissimilar names results in positive transfer. There is no basis, however, for deciding whether the similar names produced positive or negative transfer in this case. If facilitation relative to a control condition could be shown for both similar and dissimilar responses, differences in amount of transfer might reflect the different asymptotes suggested in the curves in Fig. 4.

Reese (1958, 1960) extended the Norcross design in an experiment investigating level of pretraining and verbal response similarity, using fourth-, fifth-, and sixth-grade children as subjects. The criterion task required button-pushing responses to six lights consisting of three pairs of similar hues (two red, two blue, and two green). Each subject received pretraining on two of the three pairs of hues; half the subjects learned similar nonsense syllables to the lights and the other half learned dissimilar nonsense syllables. Three times as many pretraining trials were given on one pair of lights as on the other pair; consequently, in the motor task, the three pairs of stimuli represented three levels of pretraining: high, low, and none. The design is rather complex, since it included the counterbalancing of syllable pairs, levels of pretraining, and button pairs. The basic S-R relationships in the design have been summarized by Spiker (1963a) and are shown in Table III.

During pretraining, Group S learned *zim* and *zam* (Pair A) and *wug* and *wog* (Pair B) to two pairs of stimulus lights, and Group D learned *lev* and *mib* (Pair C) and *wug* and *zam* (Pair D). Both groups were taught the appropriate set of names before they learned to associate them with the four lights. The stimuli were presented in a single aperture, one at a time, in blocks of eight, a block consisting of three presentations of each member of the "high" level pair and one presentation of each member of the "low" level pair. The lights were presented automatically, using a 4-sec anticipation interval for the first two blocks and a 2-sec interval thereafter. The experimenter gave verbal reinforcement or correction, the subject being required to repeat each correction aloud. The pretraining criterion was two consecutive blocks (excluding the first two blocks) with no errors on the high level stimuli. Subjects who did not meet the criterion within 22 blocks were eliminated.

In the instructions for the transfer task, the children were told, "The names

you just learned will help you a lot if you use them, but you do not have to say them out loud." The six buttons were arranged in a semicircle and were numbered with 1-inch high numerals. If the subject pressed the correct button for a particular light within a 3-sec anticipation interval, a bell sounded. At the end of this interval, a small light came on next to the correct button. Only one response was allowed for each stimulus. A trial consisted of one presentation of each of the six lights, and the criterion was four consecutive errorless trials or a maximum of 20 trials.

TABLE III
BASIC DESIGN OF REESE (1960) EXPERIMENT (ADAPTED FROM SPIKER, 1963a)[a]

Learning criterion in pretraining	Distinctive-name Group D (N = 36)		Similar-name Group S (N = 36)	
	Task 1	Task 2	Task 1	Task 2
High (two consecutive errorless blocks)	$S_1 \dashrightarrow R_{V_1}$ $S_1' \dashrightarrow R_{V_2}$	$S_1 \dashrightarrow R_{M_1}$ $S_1' \dashrightarrow R_{M_2}$	$S_1 \dashrightarrow R_{V_1}$ $S_1' \dashrightarrow R_{V_1}'$	$S_1 \dashrightarrow R_{M_1}$ $S_1' \dashrightarrow R_{M_2}$
Low (one-third the number of blocks for "High")	$S_2 \dashrightarrow R_{V_3}$ $S_2' \dashrightarrow R_{V_4}$	$S_2 \dashrightarrow R_{M_3}$ $S_2' \dashrightarrow R_{M_4}$	$S_2 \dashrightarrow R_{V_2}$ $S_2' \dashrightarrow R_{V_2}'$	$S_2 \dashrightarrow R_{M_3}$ $S_2' \dashrightarrow R_{M_4}$
None		$S_3 \dashrightarrow R_{M_5}$ $S_3' \dashrightarrow R_{M_6}$		$S_3 \dashrightarrow R_{M_5}$ $S_3' \dashrightarrow R_{M_6}$

[a] Reproduced by permission of the Society for Research in Child Development.

The pretraining data indicated that one of the similar verbal response pairs was more difficult to learn than the other pair, so that there were effectively three rather than two levels of similarity. Therefore, the transfer task data were analyzed for three levels of similarity, with Pair B considered to be a high level of similarity, Pair A a moderate level, and Pairs C and D (combined) a low level of similarity. The measure used to analyze the data was based on the number of within-pair errors. A within-pair error occurred when the response was appropriate for the hue similar to the one presented. The score was a percentage, defined as 100 × number of within-pair errors on a given stimulus pair divided by the total number of errors on that pair. In order to correct for different numbers of pretraining trials, a subject's percentage score on the no pretraining stimuli was subtracted from his scores on each of the other pairs. This difference score with the sign changed indicates the direction and relative amount of transfer for a particular level of pretraining and degree of similarity.

The means of the adjusted percentage scores are shown in Fig. 5. The statistical analyses indicated that both levels of pretraining on the distinctive names facilitated performance on the transfer task. With the moderately similar names, a high level produced positive transfer. The apparent instances of negative transfer were not significant. Other tests indicated that the distinctive names were superior to the moderately similar names for the low pretraining level. Furthermore, at the high level, the highly similar names were inferior to both the moderately similar and distinctive names. The results in Fig. 5 led Reese to suggest hypothetical functions very similar to those shown in Fig. 4. The specific manner in which level of pretraining and verbal response similarity presumably interact to produce transfer was described in detail in Section III, C and need not be repeated here. A comparison of Figs. 4 and 5 shows that Reese's data correspond to the left side of Fig. 4. In other words, the poor performance on the highly similar responses at the high pretraining level may have been due to inadequate learning or retention of the names.

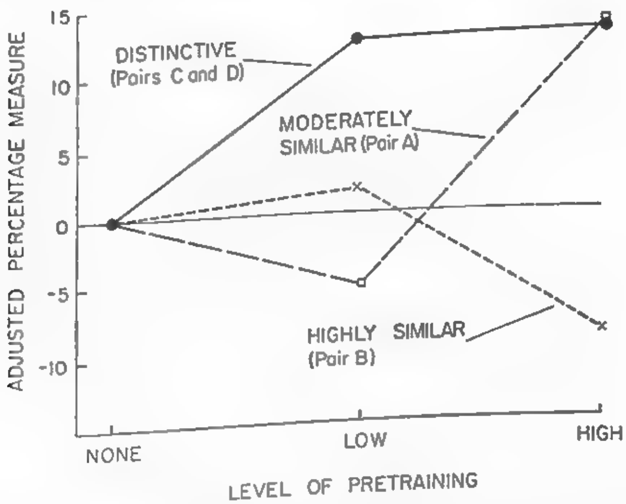

Fig. 5. Means of the adjusted percentage scores for the transfer task in the Reese (1958) experiment. Adapted from Spiker (1963a) and reproduced by permission of the Society for Research in Child Development.

These designs developed by Norcross and Reese have a number of advantages for studying the role of the verbal cues. First, the within-subjects comparisons provide a relatively high degree of precision. A second advantage is that the no pretraining condition provides a test for the direction of the transfer effects in a design that controls for nonspecific sources of transfer. Reese found clear evidence of facilitation for distinctive responses at both levels of pre-

training and for the moderately similar responses at the high level. Observing responses as well as verbal responses could account for these differences, since there were presumably no observing responses established to the control stimuli at the outset of the transfer task. Although no statistical evidence for negative transfer was found in this experiment, it may be noted that such a difference, if found, could be attributed to the verbal cues, since the observing responses would be expected to produce positive transfer.

A third advantage of this type of design is that observing responses are controlled in comparisons made between different degrees of similarity at a particular level of pretraining. Therefore, similarity differences such as those obtained at both the low and high levels of pretraining clearly seem to be some function of the verbal cues. However, all these differences could be a joint function of interference due to insufficient pretraining and facilitation due to ADC or rehearsal, and there does not as yet appear to be a way of separating these effects.

C. Paradigms 1a and 2a Combined

In a recent experiment, Katz (1963) used elementary school children to study the effects of both identical names and distinctive names on performance in a "perceptual" task and in a discrimination learning task. The stimuli were four complex nonsense shapes of the type described by Attneave (1954). One group (DL) was given paired-associate pretraining in which a different label (*buz, ric, jan,* or *sol*) was learned for each figure, and a second group (CL) associated one of the four names with one pair of figures and a second name with the other pair. The figures were presented successively, each one being exposed for 2 sec. Subjects in an attention group (NL) were instructed to count the figures as they appeared, in order to minimize the likelihood that they would supply their own labels. Eight first or second graders and eight fourth graders were assigned to each of the three groups. In the first criterion task, pairs of stimuli were presented for .2 sec, and the subjects made judgments of "same" or "different." There were 8 pairs of identical figures and 20 pairs of different figures, 10 of the latter being pairs for which the common-label group had learned identical names. The simultaneous discrimination learning task was given following the perceptual task. Three of the four figures were used as stimuli, and the positive stimulus was always one member of the pair for which Group CL had a common label. The child was rewarded for correct choices, but no correction was allowed. The criterion was five consecutive correct choices or a maximum of 50 trials.

Groups DL and CL did not differ significantly in performance during the last 50 pretraining trials. On the perceptual task, the three groups did not

differ in accuracy of the "same" judgments made to the identical pairs. However, for the ten pairs of different figures for which Group CL had common labels, the means of "same" judgments were 4.31 for CL, 3.06 for NL and 1.94 for DL. The over-all *F* for these means was significant, but tests of individual pairs of means were not reported. In the discrimination task, the groups differed in total number of correct responses, the means being 16.31 for CL, 21.25 for NL, and 25.92 for DL. No follow-up comparisons of pairs of groups were given. An additional analysis of the discrimination data showed that, on the trial following a reinforced response, CL subjects tended to choose the incorrect stimulus having the common label as frequently as they chose the correct stimulus. DL subjects, on the other hand, showed a marked tendency to choose the correct stimulus instead of the comparison stimulus for which they had a distinctive label. Group NL was midway between the other groups in this comparison. The interaction implied in these group differences was significant. No significant age effects were reported.

Although the results of this experiment were quite clear-cut, they seem to be well handled by all of the hypotheses under consideration. The data are in good agreement with predictions based on AEC and ADC. It does not seem likely that the subjects in Group NL supplied their own labels, since they counted the stimuli during pretraining and had very little time to look at them in the perceptual task. Therefore, the apparent inferiority of CL to NL in both criterion tasks could be explained in terms of increased generalization, and the superiority of DL to NL in terms of decreased generalization.

It seems equally plausible that observing responses played an important role in this situation. The stimuli were complex figures with indentations and jagged contours, and both similar and dissimilar aspects of pairs of figures could be readily identified. The CL subjects presumably learned to observe within-pair similarities and between-pair dissimilarities, whereas the DL subjects learned to observe only the dissimilar aspects of the stimuli. Since it is difficult to say what type of observing responses, if any, were learned in the NL group, this group does not provide a baseline for determining whether observing responses may have produced negative transfer in CL, positive transfer in DL, or both.

Although group differences in discrimination performance on the trials following reinforced responses could be explained similarly in terms of ADC, AEC, and observing responses, they seem to be especially well handled by the rehearsal hypothesis. The DL subjects could have spent the intertrial intervals following correct responses reminding themselves that *buz,* for example, was correct; thus, their subsequent performance would be facilitated. If the CL subjects did the same thing, then it would be expected that they would be equally likely to pick either of the two *buz* figures on the next trial. The NL subjects, presumably having no labels for the stimuli, would have had no basis for rehearsal.

D. Paradigm 2b or 2d

The experiments that will be reviewed in this section have usually been called studies of mediated or secondary generalization. While the multistage designs conform generally to the simplified version in paradigm 2d, they are usually considerably more complex. For this reason, it will be necessary to limit the amount of detail on procedures and describe only the major aspects of the design and results.

Birge (1941) used third-, fourth-, and fifth-grade children in two experiments in which the basic design was paradigm 2d. Relevant S pretraining was given in the first phase, and discrimination learning tasks were used in the second and third phases. Four nonsense animal figures attached to wooden boxes were presented successively in the first phase, and the children learned to label two of the figures *meef* and the other two *towk*. The criterion in this phase was 16 consecutive correct responses. One meef box and one towk box were presented, and the child was told to find the candy. Counterbalancing under the box arbitrarily designated as correct. The criterion was four consecutive choices of the correct box. The final phase was a test consisting of a single trial in which the other meef and towk boxes (those not used in Phase 2) were presented, and the child was told to find the candy. Counterbalancing procedures were used to control for spatial positions of the boxes, name preferences, and differential similarity of pairs of figures. In the first experiment, four experimental groups ($N = 26$ per group) differed in the amount of overt verbalization required in the second and third phases. Group V-0 did not verbalize overtly in either of the latter phases, Group V-2 said the name of the figure before choosing a box in the second phase, Group V-3 said the name before choosing in the third (test) phase, and Group V-2-3 verbalized in both phases. The design for one counterbalancing subgroup in the V-2-3 condition is shown in Table IV. It was expected that the figure chosen on the

TABLE IV
Basic Design of Birge (1941) Experiment
(V-2-3 Condition)

Phase 1	Phase 2	Phase 3 (test)
$S_A \dashrightarrow R_{\text{"meef"}}$ $S_B \dashrightarrow R_{\text{"meef"}}$	$S_A \dashrightarrow R_{\text{approach}}$ $\searrow R_{\text{"meef"}}$	$S_B \dashrightarrow ?$ $\searrow R_{\text{"meef"}}$
$S_C \dashrightarrow R_{\text{"towk"}}$ $S_D \dashrightarrow R_{\text{"towk"}}$	$S_C \dashrightarrow R_{\text{not approach}}$ $\searrow R_{\text{"towk"}}$	$S_D \dashrightarrow ?$ $\searrow R_{\text{"towk"}}$

test trial would be the one having the same name as the figure that was correct in the second phase, presumably because of secondary generalization.

The percentages of choice of the same-name box for Groups V-0, V-3, V-2, and V-2-3 were 54, 62, 77, and 85. Chi-square tests indicated that Groups V-2 and V-2-3 were significantly above chance (50%).

A second experiment using slightly modified procedures compared V-0 and V-2-3 groups ($N = 24$ per group), and the results were essentially the same as in the first experiment. The percentages of choice of the same-name box were 54 and 84 for Groups V-0 and V-2-3, and the latter percentage was significantly greater than 50%. Furthermore, a chi-square test of the interaction between groups and direction of choice was significant (Spiker, 1953).

It does not appear to have been generally recognized that the results of these experiments, and of most other experiments using this paradigm, can be explained in terms of the ADC as well as the AEC hypothesis (Shepard, 1954). A subject's choice of S_B in phase 3 could be attributed, on the one hand, to increased similarity of the S_A and S_B complexes, the correct response occurring on the test trial by direct mediation via the association, $s_{meef} \rightarrow R_{approach}$, learned in Phase 2. On the other hand, the similarity of the S_A and S_D complexes should be *reduced* by the addition of the distinctive cues, s_{meef} and s_{towk}. Likewise, the similarity of the S_C and S_D complexes should be increased, and that of the S_C and S_B complexes, decreased.

A parallel analysis can be made in terms of observing responses. The subjects may have learned in Phase 1 to attend to those aspects of the two meef figures that were similar and also to those aspects which differentiated the meef figures from the towk figures. The changes in the effective external stimuli would presumably result in increased generalization between the meef figures and decreased generalization between the meef and towk figures.

Jeffrey (1953) was interested in studying both verbal and motor mediation in preschool children. A verbal mediation group, a motor mediation group, and a control group each contained 16 subjects. Although the five-stage design was rather complex, it consisted basically of a motor learning phase, followed by a phase in which either verbal labels or new motor responses were associated with the stimuli. The responses learned in the latter phase were then set up as mediators of the original motor responses. The design for the verbal mediation group in one counterbalancing condition is shown in Table V. It can be seen that Phases 3, 4, and 5 correspond to the three phases in paradigm 2d. In Phase 1, subjects learned to push a handle to a black stimulus and pull the same handle to a white stimulus. A test series was then introduced in which a gray stimulus was occasionally interspersed with the black and white to measure the initial tendency to generalize to the gray. In the third phase, subjects learned to name the black and white stimuli and to call the gray stimulus *black*. The mediation was established in the fourth phase by having

the subjects name the black and white stimuli before they made the previously learned motor responses. In the final test phase, gray was re-introduced into the series, and the subjects named each stimulus before making the motor response. It was expected that the name learned to the gray stimulus would mediate the response associated with the black stimulus. For the motor mediation group, right and left handle-turning responses were substituted for the naming responses throughout the experiment. The control group was like the motor group except during the fourth and fifth phases, when the handle was locked so that the mediating motor response (turning

TABLE V
BASIC DESIGN OF JEFFREY (1953) EXPERIMENT
(VERBAL MEDIATION CONDITION)

Phase 1 Motor training	Phase 2 Test 1	Phase 3 Verbal training	Phase 4 Mediation training	Phase 5 Test 2
	$S_B \rightarrow R_{Push}$	$S_B \dashrightarrow R_{\text{"black"}}$		$S_B \rightarrow R_{Push} \searrow R_{\text{"black"}}$
$S_B \dashrightarrow R_{Push}$			$S_B \rightarrow R_{Push} \searrow R_{\text{"black"}}$	
	$S_W \rightarrow R_{Pull}$	$S_W \dashrightarrow R_{\text{"white"}}$		$S_W \rightarrow R_{Pull} \searrow R_{\text{"white"}}$
$S_W \dashrightarrow R_{Pull}$			$S_W \rightarrow R_{Pull} \searrow R_{\text{"white"}}$	
	$S_G \rightarrow ?$	$S_G \dashrightarrow R_{\text{"black"}}$		$S_G \rightarrow ? \searrow R_{\text{"black"}}$

right or left) could not occur. The particular motor responses assigned to the stimuli were counterbalanced, and so was the response associated with the gray stimulus.

The effects of the mediation training were analyzed in terms of a difference score based on the number of responses in the predicted direction in the two test phases. A difference of +12 was the highest possible score in the direction predicted by the AEC hypothesis. The means of the difference scores for the verbal mediation, motor mediation, and control groups were 6.31, 4.25, and 1.88. The differences between these means were all significant, and it was further found that the control group exceeded chance in responding in the mediational direction.

Jeffrey's results seem to provide strong support for the role of verbal and motor cues in changing generalization. As in the Birge study, both AEC and ADC can account for the results. In other words, the tendency to push the handle to gray could be due to both increased similarity of the black and gray

stimulus complexes and to decreased similarity of the white and gray complexes. It seems unlikely that observing responses played an important role with stimuli varying only in brightness. In this study, as well as in the Birge study, rehearsal could not account for the results, since the criterion measures were obtained in a test phase rather than in a learning task. Jeffrey noted that the apparent occurrence of mediation in the control group, in spite of the fact that they received no mediational training, may have been due to the use of subject-supplied labels for the stimuli. If this were the case, part of the transfer in the motor mediation group could also be explained in terms of such subject-supplied verbal mediation.

Shepard (1956) used a design very similar to Jeffrey's to study the relative effects of verbal mediation training for different degrees of stimulus similarity. The stimuli were colored lights varying along a hue dimension (red, red-orange, orange, yellow, blue). The effects of verbal mediation training on generalization of a response learned to red were assessed at various points along the hue dimension. Eighteen preschool children were assigned to each of three experimental groups and five children to a control group. In Phase 1, all groups were taught to push a button to the red light and not to push it to the blue light. In Phase 2, each of the intermediate hues (red-orange, orange, and yellow) was assigned to one of the experimental groups and served as a generalization test point. The third test point (yellow) was also assigned to the control group. The test stimulus was occasionally interspersed with the red and blue lights in this phase to provide an initial generalization test. Phase 3 provided the name learning for the experimental groups, but was omitted for the control group. All experimental groups learned the name *mo* to both the red light and the test light, and *lee* to the blue light. In Phase 4, the red and blue lights were again presented. The experimental groups gave the appropriate names and pushed the button to the red stimulus. The control subjects made the same motor response, but not the naming responses. The final phase was a generalization test like the first test except that the experimental subjects were required to name each light as it appeared.

The data were analyzed in terms of the proportion of button-pushing responses made to each test stimulus. At the first test point (red-orange), the proportions for the first and second generalization tests were .80 and .91. The proportions at the second test point were .24 and .44, and at the third test point, they were .22 and .65. The control group, given the third test point, had a proportion of .33 in both tests. The increases from the first to the second test for the experimental groups were significant at test points 2 and 3, but not at point 1. No test of the interaction was available because of non-normality in the data.

It appears that the effects of AEC were greater as the similarity between the original training stimulus (red) and the test points decreased. It could

also be argued that the mediation training resulted in ADC, and that this effect was a decreasing function of the difference between the blue light and the test points. This argument assumes that an avoidance response was learned to the negative stimulus (blue light in this experiment) in the discrimination learning task. Shepard also pointed out that the small change at test point 1 may have been due to a ceiling effect. It is difficult to see how these findings could be handled adequately in terms of observing responses. Since the control group did not have the verbal training, it could be argued that they had no reason to look for similarities between the yellow and red hues and dissimilarities between the yellow and blue hues. However, it is difficult to specify or even imagine what kinds of observing responses might be learned to such simple and homogeneous stimuli.

Shepard (1954) used a variant of pardigm 2b in which performances of relevant S and irrelevant groups were compared on a criterion task requiring a lever-pulling response to one subset of stimuli and no response to another subset. Forty-eight preschool children served as subjects in two experimental sessions. During relevant pretraining, five nonsense figures were presented simultaneously, and the children learned the name *ding* for three of them and *ho* for the other two. Children in the control group learned the same names to a comparable, but irrelevant set of figures. The criterion in the first session was three successive trials in which all five figures were correctly named. In the second session, the figures were presented successively, and verbal training was continued to the same criterion. The criterion task followed immediately, and subjects were required to pull a lever to the ding figures and not to pull to the ho figures. Correct verbal responses in pretraining and correct pulling responses in the motor task were rewarded with chips later cashed in for a toy. Eleven motor learning trials were given, each trial consisting of one presentation of each figure. It was expected that, for the relevant group, the identical verbal cues associated with the stimulus subsets would facilitate the learning of the approach and avoidance responses in the criterion task.

The results were analyzed separately for errors to the "correct" stimuli (not pulling to the ding figures) and for errors to the "incorrect" stimuli (pulling to the ho figures). The relevant group made significantly fewer errors to the incorrect stimuli ($\bar{X} = 3.17$) than did the irrelevant group ($\bar{X} = 7.13$), and the groups did not differ in errors to the correct stimuli.

Shepard indicated that there was evidence of some initial generalization among the figures, so that either AEC or ADC could account for the findings. The observing responses learned by the relevant group could also have facilitated performance in the same manner discussed with reference to the Birge experiment. Furthermore, rehearsal in the criterion task may have been a potent factor in producing positive transfer.

VI. Concluding Comments

In spite of the fact that the verbal response and observing response hypotheses have been examined in terms of a relatively small number of experiments, there are several reasons why it may nevertheless be helpful to base some general conclusions on the studies reviewed. First, it is the writer's opinion that these studies done with children not only contain the most recent data, but have used designs that provide the most valuable information collected to date about the hypotheses under consideration. Secondly, the results of the child studies are in general agreement with findings from experiments with adult subjects. Finally, although there are other kinds of studies (both child and adult) in which the same hypotheses may be used to explain the findings, problems in interpretation due to confounding of the various effects also exist in these situations. Thus, consideration of related studies might provide evidence of greater generality for a particular hypothesis, but it would not be likely to aid in the evaluation of that hypothesis in isolation.

One of the clearest findings is facilitation in paradigm 1a; in other words, pretraining in which distinctive names are learned for similar stimuli produces positive transfer that cannot be attributed to non-specific factors. Strong evidence has been presented for the conclusion that there are situations in which this facilitation can best be explained by reference to the transfer of verbal responses. The emphasis placed in this paper on the role of verbal cues is not intended to minimize the importance of observing responses. Studies of this paradigm have usually been designed to test the ADC hypothesis, and interest in observing responses is relatively recent. Few investigators have as yet designed experiments to maximize the role of observing responses in producing transfer. However, such data are not entirely lacking. Kurtz (1955) and Spiker and Hawkins (1962) have shown that learning to attend to particular relevant aspects or dimenisons of the stimuli during pretraining produces either positive or negative transfer, depending upon whether the same aspects of the stimuli are relevant or irrelevant in the transfer task. Similarly, little systematic work has been done as yet to test the rehearsal hypothesis. In one study using adult subjects (Peters, 1963), instructions to rehearse did not increase the amount of positive transfer. However, it seems likely that even uninstructed adult subjects would tend to rehearse during intertrial and interstimulus intervals. For this reason, young children would seem to be ideal subjects for further study of the rehearsal hypothesis.

The data also support the conclusion that positive transfer occurs in paradigm 2d, in which a verbal response can be used as a direct mediator of the correct criterion response. Again, the emphasis in the literature has been on the

transfer of verbal responses in this paradigm, and more specifically, investigators have been interested in the AEC hypothesis and the role of secondary generalization. Little or no attention has been given to observing responses or rehearsal in this experimental situation.

The findings with respect to negative transfer following stimulus pretraining are far less clear-cut. The data suggest that negative transfer is obtained in paradigm 2a, in which differential motor responses are required following the learning of identical names for the stimuli. Little can be said at the present time about paradigm 3a, in which similar verbal responses are learned. The data suggest that verbal response similarity and level of pretraining interact in producing transfer, but independent data have not yet been collected to test the hypothesis about the nature of this interaction.

One conclusion which seems inescapable is that we are not likely to find that any of the hypotheses are either "correct" or "incorrect." Rather, we will probably find that the particular stimuli, responses, and design used will determine the relative importance of the verbal cues and observing responses.

Perhaps the obvious final conclusion is that there are more questions raised by these experiments than conclusions to be drawn from them. Although many of these questions seem to be unanswerable because of control problems, there appear to be many other questions whose answers do not depend upon the development of designs or techniques, but rather on the collection of new data.

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THE ROLE OF THE DISTANCE RECEPTORS IN THE DEVELOPMENT OF SOCIAL RESPONSIVENESS[1]

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During the past 25 years, the development of social responsiveness in infancy and childhood has most frequently been structured in terms of the establishing of dependency habits and the emergence of a dependency drive (e.g., Dollard & Miller, 1950; Sears *et al.*, 1953, 1957). In a recent discussion of the

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relationships among such variables as dependency, social deprivation, and various measures of social influence, Walters and Parke (1964), after pointing out that the concept of dependency, like many other social "variables" employed by child psychologists, is semi-evaluative in nature, offered an alternative analysis of the learning of social behavior in terms of the eliciting and modification of orienting and attending responses. This analysis led to the suggestion that the role of the distance receptors is of paramount importance in the development of social responsiveness in infancy and early childhood. In this paper, the authors attempt to marshall evidence, most of it of very recent date, that lends support to this suggestion.

I. Caretaking and Nursing Situations

An amalgam of psychoanalytic and Hullian learning theory led to an emphasis on the mother-child feeding relationship as the crucial context within which the infant develops its capacity for social responses (e.g., Sears *et al.,* 1957). This relationship supposedly provided an unique opportunity for the association of the mother's presence and activities with the reduction of the frequently occurring primary drive of hunger, as a result of which these maternal characteristics were endowed with acquired secondary-reward value. Although the alleviation of infant distress other than that caused by hunger was seen as contributing to the mother's reward value, the Freudian influence [e.g., Freud (1953, originally published in 1905)] channeled attention to the oral behavior of the infant to such an extent that orality and dependency have sometimes been utilized as overlapping, if not precisely equivalent, terms (Murphy, 1964).

Recent research indicates that the feeding agent is not invariably the primary object of the infant's early social responses. Harlow (1958), using as subjects infant rhesus monkeys, demonstrated that "contact comfort" was considerably more important than feeding as an antecedent of attachment behavior. The infants had access to two inanimate mother surrogates; one surrogate was constructed from a block of wood, covered with sponge rubber and soft terry-cloth and warmed by radiant heat, while the other was constructed from wire-mesh and unheated. Half the infants were fed on the cloth mother and the remainder on the wire-mesh mother. Infants fed on the lactating wire mother spent decreasingly less time in contact with her and increasingly more time with the nonlactating cloth mother, "a finding completely contrary to any interpretation of derived drive in terms in which the mother-form becomes conditioned to hunger-thirst reduction" (p. 676). Subsequent reports from Harlow's laboratory (Harlow, 1960, 1961; Harlow & Zimmerman, 1959) confirmed the initial findings. Moreover, they indicated that in the presence of a fear stimulus infant monkeys will seek the proximity of a cloth mother

in preference to that of a wire mother and will also favor the cloth mother as a safe base from which to explore the environment; these preferences were manifested even when the wire mother was the source of nutrition.

Harlow emphasizes the role of contact comfort in the establishment of affectional behavior; while this variable may be of primary importance for the development of social responsiveness in subhuman mammals, in which motor responses are relatively well developed early in infancy, there is reason to believe that it is of far less importance in human social development.

Schaffer and Emerson (1964a) collected data concerning the attachment behavior of human infants during the first year and a half of life. Mothers were interviewed at 4-week intervals from the time that the infants were 2 to 5 months old until they reached the age of 1 year and once again when the infants were 18 months old. Protest behavior (whining, moaning, crying) in seven different situations in which the infant's contact with other persons was interrupted provided indices of age of onset, intensity, and breadth of attachments. The investigators found that specific attachments were formed to individuals who never participated in routine caretaking activities and consequently questioned the view that social behavior arises primarily in the context of the feeding situation. "Satisfaction of physical needs does not appear to be a necessary precondition to the development of attachments, the latter taking place independently and without any obvious regard to the experiences that the child encounters in physical care situations" (Schaffer & Emerson, 1964a, p. 67).

Schaffer and Emerson report several findings that support their conclusion. Attachment behavior is at first indiscriminate; during the first 6 months of life the infant protests the withdrawal of anyone's attention, familiar or strange, and it is only around the seventh month that specific attachments are manifested. Not all infants initially develop a single specific attachment; over a quarter of the infants observed displayed multiple attachments as soon as any specificity was apparent. Moreover, even at the onset of the formation of specific attachments, the mother was not inevitably the single, or sole principal, object of attachment.

Data collected when the infants had reached 18 months of age indicated that neither rigidity of feeding schedule nor age of weaning was related to the strength of attachment to the mother; however, there were fairly strong relationships between two variables relating to the mother's social responsiveness—the mothers' responsiveness to the children's crying and the extent to which they interacted with the children—and the degree of the children's attachment to their mothers. Three modes of interaction were distinguished: a personal approach involving a great deal of physical contact with the child, a personal approach primarily involving stimulation by the mother's voice and facial expressions, and an impersonal approach in which the mother diverted

attention from herself through providing the child with toys, food, and other objects when he demanded attention. Infants whose mothers used physical contact as their preferred mode of interaction were no more intensely attached to their mothers than infants whose mothers preferred one of the other two modes. In addition, intrafamily comparisons indicated that a child's principal object of attachment tended to be a person who interacted intensely with him and was highly responsive to his demands for attention, but not necessarily the person who was most available to him or who performed the caretaking routines. For 22 of the infants, the principal objects of attachment had not participated at all in any aspect of the caretaking process.

The breadth of the children's attachment behavior at 18 months was positively related to the number of persons with whom they interacted, whether in a caretaking capacity or otherwise, but was not related to the number of persons with whom they interacted solely in a caretaking capacity. This finding lent further support to the investigators' contention that it is stimulation in general, and not simply the satisfaction of physical needs, that develops attachment behavior.

In view of the failure of Schaffer and Emerson to find any relationship between socialization variables related to early feeding experiences and infants' attachment behavior at 18 months, it is not surprising that attempts to relate such experiences to later dependency behavior have met with little success. Sears *et al.* (1957), in a report based on mother-interview data, found no relationship between the warmth of mothers toward their infants, defined essentially as a physical-contact variable, and the children's dependency behavior at age 5; breast-fed children were no more dependent than bottle-fed children; duration of breast or bottle feeding, age at commencement and termination of weaning, and duration of weaning were all similarly unrelated to later dependency behavior. Equally negative results were reported in an earlier study by Sears *et al.* (1953).

The mounting evidence against the widely held view that gratification of an infant's "oral needs" is necessarily the principal antecedent of social responsiveness does not, however, imply that the feeding situation itself is not of considerable importance for the development of attachment to the mother. During feeding, the majority of human mothers provide their infants with considerable auditory and visual stimulation, as well as with physical contact. Haynes *et al.* (1965) discovered that alert infants in the early weeks of life have a fixed point of clearest vision at 8 or 9 inches and that objects either closer or farther away cannot be brought into sharp focus. Under normal feeding and other caretaking conditions the mother's face is frequently exposed at this optimal distance for patterned vision. Consequently, in caretaking situations, the infant has many opportunities for the development of social responsiveness on a purely perceptual basis (Fantz, 1965; Rheingold, 1961).

Moreover, the human face is demonstrably an object complex and mobile enough to hold the infant's attention. The relationship between complexity and infant attention has been the subject of several investigations. In a pioneering study, Berlyne (1958) presented infants of 3 to 9 months with stimuli of varying degrees of complexity. The stimuli were presented in pairs, and an observer recorded which stimulus in each pair was fixated first. Stimuli containing a relatively large amount of contour were more likely to attract initial fixations than were less complex stimuli. A more recent experiment by Spears (1964), who employed a wider range of stimuli of varying forms and colors, provided further evidence of the importance of complexity as a determinant of infant attention. Analogous findings have been reported for preschool children by Cantor *et al.* (1963).

Fantz's investigations are more directly relevant to the issue under discussion in this paper. In his initial study, Fantz (1958) recorded the times that infants spent looking at stimuli of varying complexity; records were obtained at weekly intervals from the first to the fifteenth week of life. At all ages tested, the infants were able to discriminate the different patterns and showed preferences for the more complex stimuli. In a later study, Fantz (1961) utilized three flat objects, similar to a head in size and shape. On one stimulus was painted a schematic face pattern; on the second stimulus, facial features were presented in a scrambled pattern; the third, control stimulus retained the brightness value of the other stimuli but contained no facial features. Most infants within the age range of 1 month to 6 months exhibited a preference for the schematic face. Subsequently, Fantz (1961) assessed the preferences of infants in relation to six test objects, three patterned and three plain. The patterned objects—a face, a bull's eye, and a patch of printed matter—were all preferred to the plain objects; moreover, the face was overwhelmingly preferred to the other patterned stimuli.

Fantz (1965) next compared the effectiveness of a life-size model of the human head and that of a flat form of the same outline for eliciting infant attention. During the first 2 months of life infants preferred the flat form; however, in the third month there was a marked shift to a preference for the three-dimensional head. These preferences were apparent even when the test objects were viewed monocularly.

Fantz's investigations were designed to determine the relative contribution of innate factors, maturation, and learning to the development of form perception. However, his findings also seem to have important implications for social development. The infant's visual preferences may facilitate the early nonspecific attachments that infants display to other humans; in addition, they may promote the recognition and discrimination of facial features and thus contribute to the formation of specific attachments.

Kagan and Lewis (1964) recently reported preliminary results of an impor-

tant longitudinal investigation of attention in infants. At 6 months of age, the infants were presented with two types of visual patterns—pictures of faces and geometrical designs—and three patterns of blinking lights. In addition, five auditory stimuli were presented: an intermittent tone, a selection of unusual jazz music, and three human voices each reading the same paragraph of English—a female voice, a male voice, and the voice of each child's own mother. The experimenters recorded the time for which the infants fixated each of the visual patterns; in addition, changes in the infants' motor activity and the vocalizations that occurred during the presentations of each of the visual and auditory stimuli were recorded. On the basis of previous findings with children and adults (Kagan & Rosman, 1964; Lacey, 1959; Lacey *et al.*, 1963), cardiac deceleration was selected as an additional, physiological index of attention.

Kagan and Lewis found that photographs of male and female faces elicited more sustained attention than nonhuman visual stimuli, which included a nursing bottle. Moreover, the female face elicited more vocalizations than the male face, suggesting that 6-month-old infants were able to differentiate between male and female faces. Of the three light patterns, the most complex appeared to elicit maximum attention, a finding that may be interpreted as supporting Fantz's claim that the attention value of the human face for infants is due, in part at last, to its complexity.

As he interacts with a caretaker, the infant not only experiences a constantly changing configuration of facial features but also frequently receives stimulation from the human voice. The role of auditory stimulation both within and without the caretaking situation has not yet been sufficiently explored. Kagan and Lewis found that on first being presented with human voices, especially that of a strange female, infants exhibited cardiac deceleration and quieting, followed by vocalization. On the basis of this finding, Kagan and Lewis suggest that human speech acquires psychological significance by the time an infant has attained the age of 6 months. Their suggestion is supported by Wolff's (1963) observations on infant smiling, which are reviewed in the following section.

The conclusion that may be drawn from the limited avaliable evidence is that visual and auditory stimulation occurring during caretaking plays an important role in the development of social responsiveness. This conclusion does not, however, imply that physical-contact and need-reduction variables do not contribute to this development. Igel and Calvin (1960), in a study that paralleled in some respects Harlow's original experiment with mother surrogates, found that infant puppies preferred a lactating "comfortable" surrogate to an equally "comfortable" surrogate on which they were not fed. Similarly, one would expect a human infant to form a stronger attachment to a caretaker who feeds, provides contact-comfort, and visual and auditory stimulation than

to one who supplies a similar amount of stimulation through the distance receptors but provides little contact comfort or participates minimally in the feeding situation.

II. Eliciting of Smiling Responses

Smiling has frequently been employed as an index of social responsiveness. In the first 2 weeks of life, most smiling is more dependent on the infant's internal state than on the occurrence of external stimulation, and is, therefore, of little social significance. By the third week, however, the infant smiles differentially to various kinds of external stimulation while wide awake. At this stage, smiling may be regarded as a social response (Wolff, 1963).

On the basis of repeated observations in standard situations, Washburn (1929) reported that a smiling human face was the most effective stimulus for eliciting similing and laughing in infants during the first year of life. Kaila (1932), working under the influence of Gestalt theory, presented evidence in support of the view that infant smiles are evoked by the stimulus configuration of a frontal view of a human face though not by a profile configuration. The effectiveness of the sight of a human face for eliciting infant smiles is also evident from Dennis' (1935) observations on two infant girls. Dennis noted that practically all smiles occurring after the first month and a half of an infant's life were evoked before the experimenter had made physical contact with the infant. Moreover, very few smiles occurred during or after feeding.

Spitz (1946b) studied the effectiveness of a variety of human and nonhuman objects for evoking smiling responses in infants. He reported that whereas human objects, such as the experimenter's face, masks, and a scarecrow, effectively elicited smiling, nonhuman objects were incapable of eliciting smiles. Moreover, Spitz claimed that movement of all or part of a specific configuration consisting of two eyes, a nose, and a forehead was essential for evoking a smile. Spitz did not present adequate data in support of this claim, which subsequent investigators have failed to substantiate. While these investigators have generally agreed that the human face in movement is a very effective elicitor of smiles, their data indicate that the sight of a moving human object is not a necessary antecedent of infant smiling.

Recent evidence suggests that sounds are at first more effective than visual stimuli for evoking social smiles in infants. In a longitudinal study, Wolff (1963) found that, as early as the third week, social smiles were more frequently evoked by a high-pitched human voice than by a variety of other auditory stimuli. Very shortly afterwards, visual stimulation contributed to the eliciting of smiles; by the end of the third week, the sight of a nodding human head, accompanied by the sound of the voice, was for some infants a more

effective stimulus than the voice alone. During the fourth and fifth weeks, the sight of a silent human face was a sufficient condition for the eliciting of smiles, provided that there was eye-to-eye contact between infant and observer or the observer's face was moving.

Wolff's observations, although based on a sample of only four subjects, provide fairly convincing evidence of the effectiveness of stimulation through the distance receptors for eliciting social smiling. Unfortunately, Wolff did not test the effectiveness of proprioceptive-tactual stimulation until the third week, when he introduced a game of "pat-a-cake," involving contact of the observer's and the child's hands. During the game the child could not see or hear the observer or any other adult. Proprioceptive-tactual stimulation of this kind failed to evoke smiles until between the fourth and sixth weeks. The later emergence of smiling to proprioceptive-tactual than to auditory or visual stimulation provides some evidence in favor of the view that social responsiveness is primarily based on stimulation through the distance receptors. It is possible, however, that if Wolff's infants had experienced the "pat-a-cake" stimulation from the first week, they would have responded to it earlier. According to J. B. Watson (1924), tactual and kinaesthetic stimuli, such as light touches on sensitive areas of the body, blowing on the body, tickling under the chin, and gentle jogging or rocking are capable of eliciting smiling of a nonsocial nature as early as the fourth day of life; the exact age at which tactual and kinaesthetic stimuli of these kinds become capable of eliciting social similing has yet to be established.

Wolff's study indicated that the human head was effective for eliciting smiles in the fourth and fifth weeks only if it was in movement or there was eye-to-eye contact between infant and observer. Ahrens (1954a,b) and Ambrose (1961) have also emphasized the importance of movement and eye-to-eye contact. The available data suggest that very few infants commence to smile at a stationary, immobile human face before they are 6 weeks of age, but that most infants will smile at such a stimulus by the eighth or ninth week of life (e.g., Ambrose, 1961; Gewirtz, 1965).

Salzen (1963) investigated the responses of an 8-week-old infant to a variety of nonhuman visual stimuli. Smiling was induced by cardboard ovals—white, black, or black and white—and also by a light source with a reflector. Rotation increased the effectiveness of the cardboard stimuli and flashing increased the effectiveness of the light source. Similarly, the normal mobility of the human face may contribute immensely to its potency as a social stimulus for infants.

Ambrose (1961) studied the response strength of smiling to a stationary unsmiling human face in institution infants, 8 to 26 weeks old. The stimulus was presented for half-minute periods, separated by 30 second intervals that were utilized for recording the infants' responses to the stimulus; the series was continued until either smiling ceased or twelve successive presentations

had been made. The infants' total smiling time during a series of presentations served as the dependent measure. Infants of 8 to 11 weeks of age did not respond at all to the stationary face, and very little smiling occurred among infants between eleven and fourteen weeks of age. From 14 weeks on, all infants smiled; smiling time was at a maximum in the 17–20-week period, and declined thereafter. These findings are corroborated by data secured by B. L. White (1964).

A comparison of home-reared and institution infants indicated a similar pattern of responsiveness among the two groups; however, smiling occurred to the stationary face as early as 6 to 10 weeks among home-reared infants and reached a peak within the age range of 11 to 14 weeks. Ambrose suggests that smiling is more frequently elicited and more often reinforced among home-reared infants than among infants reared in institutions. Consequently, through more rapid instrumental conditioning, the smiling response reaches peak strength earlier among home-reared infants. At the same time, "with maternal care conditioning of the classical variety probably also takes place more rapidly than with institutional care, with the result that there is a more rapid learning of the characteristics of the face or faces which elicit smiling" (Ambrose, 1961, p. 195). Ambrose proposes that on account of this more rapid classical conditioning, home-reared infants learn sooner than institution infants to discriminate the faces of strangers from those of caretaking adults; consequently, the home-reared infants show an earlier decline in smiling to a relative stranger.

The difference in timing of smiling-response patterns among home-reared and institution infants may be in part due, as Ambrose notes, to a difference in the difficulty of the discriminations that home-reared and institution infants have to make. The former infants, generally speaking, experience more intensive and continuous interaction with a very limited number of adult figures, whereas the latter are usually cared for by a number of adults of varying degrees of familiarity. The institution infant may therefore take longer to learn to discriminate familiar from relatively strange faces. One may suspect that infants from different institutions vary considerably in the timing of the emergence of indiscriminate and discriminative smiling, with the time-patterns depending on the caretaking arrangements of the various institutions.

Data recently secured by J. S. Watson (1964), using as stimuli both the experimenter's face and the faces of infants' mothers, suggest that the development and waning of the smiling response among home-reared infants is contingent on the presentation of the face stimulus in an upright position. With upright face stimuli, Watson obtained results comparable to those reported by Ambrose. In contrast, face stimuli that were presented upside down or at a 90-degree angle were relatively ineffective for eliciting smiles from infants ranging in age from 7 to 26 weeks. If, as Watson believes, caretaking activities,

such as feeding and diaper-changing, tend to be carried out with a 90-degree presentation of the caretaker's face, his data provide further evidence that the development of smiling as a social response is relatively independent of primary-drive reduction.

Watson's finding that smiling waned to the mother's, as well as to the experimenter's, face after the infants had attained the age of 13 to 14 weeks led him to call in question Ambrose's interpretation of waning as an indication that discrimination of strangers had been achieved. This finding may, however, result from Watson's use of a smiling, but otherwise completely unresponsive, maternal face, which may well constitute an "unfamiliar" stimulus for most infants.

Ambrose (1961) noted that for both home-reared and institution infants the response strength of smiling waned over a single series of presentations of the experimenter's face in a single day. Smiling commenced at a relatively high level on the first presentation and gradually declined as the presentations were continued. This finding is not surprising in view of the fact that the experimenter's face was stationary and nonresponsive. A similar phenomenon of habituation (or extinction) was observed by Wolff (1963), who noted, however, that smiling could be readily re-elicited if the stimulus pattern were changed through movement, for example, of the tongue, or through the addition or removal of a stimulus component such as a pair of sunglasses.

Data from various cultures (e.g., Ainsworth, 1963; Geber, 1960; Gewirtz, 1965) indicate that the speed at which smiling and other infant social responses develop is profoundly influenced by caretaking arrangements. Generally speaking, social development appears to be most rapid when these arrangements permit a great deal of sensory stimulation in a wide variety of social-interaction situations. The remarkable precociousness of Ganda infants (Geber, 1960), who lift their heads and smile by 1 month and whose social development through the first year of life is generally accelerated, may be due to their being carried in a seated position on the mother's back, a vantage point that provides them with a considerable amount of visual and auditory stimulation as the mother carries out her daily activities.

Brackbill (1958) investigated the instrumental conditioning of the smiling response in eight infants between the ages of 3½ and 4½ months. During the baseline period and again during an extinction period that followed the conditioning, the experimenter stood motionless and expressionless with her face about 15 inches away from the infant's. During the baseline period, smiles were emitted by all eight infants who were subsequently exposed to the conditioning procedure; data from a ninth subject for whom the baseline procedure was extended for a period of nineteen 5-minute intervals indicated that smiling declines and eventually ceases to a nonresponsive face. These findings are substantially in agreement with those reported by Ambrose (1961).

After securing operant rates of response, Brackbill placed four infants on a continuous reinforcement schedule and the remaining four infants first on a continuous, then on an intermittent, schedule. Reinforcement consisted of the experimenter's smiling in return, speaking softly to the infant, picking it up, patting it, and talking to it. All infants were reinforced for every smiling response until they gave no fewer than four responses during each of ten consecutive 5-minute intervals. After criterion had been reached, one group of infants was reinforced first on a 2:1 variable-ratio schedule, then on a 3:1 variable-ratio schedule, and finally on a 4:1 variable-ratio schedule, while the second group continued to receive reinforcement for every response. Infants placed on the intermittent-reinforcement schedule markedly increased their rates of smiling as reinforcements were less and less frequently given. During thirteen 5-minute extinction intervals, there was a decline in the mean number of responses given by both groups of infants; however, the infants who had been intermittently reinforced responded at a significantly higher rate.

Brackbill recorded the incidence of protest (crying and fussing) responses. As smiling increased, protests decreased, and vice versa. Brackbill (1958, p. 123) conceptualized her results in terms of a habit hierarchy of two responses (smiling and protest) "for which the initially differing habit strengths were first reversed by selectively reinforcing only the weaker response, and then reversed again by extinguishing that response, allowing for recovery of the first."

The major significance of Brackbill's study lies in its demonstration that the smiling response may be strengthened or weakened according to well-established learning principles. Brackbill's reinforcer involved physical-contact, auditory, and visual stimulation; consequently, the relative importance of these components cannot be assessed. It is probable that conditioning would have occurred if physical contact or auditory and visual stimulation had been separately employed as reinforcers.

Investigators are in disagreement concerning the genesis of smiling responses. Some writers have regarded smiling as innately determined (Bühler, 1930; Goodenough, 1932; Spitz, 1946b), while others have laid emphasis on the role of instrumental or classical conditioning (Brackbill, 1958; Dennis, 1935; Gewirtz, 1965; Thompson, 1941; Washburn, 1929). Smiling occurs so soon after birth that there can be little doubt that smiling, as a physiological response, is innately determined. The question remains whether there is an unconditioned stimulus or "releaser" that evokes a *social* smile. Recent evidence (e.g., Wolff, 1963) suggests that certain auditory or visual stimuli may be "releasers" of this kind. While no definite conclusion can be reached on this point, there is no doubt that social smiles are to a large extent elicited, maintained, and modified through the presentation of visual and auditory stimuli.

III. Stimuli Eliciting Vocalizations

There has been no systematic study of the kind of social events that elicit infant vocalizations, other than distress signals, or of the ages at which infants first vocalize to different classes of social objects or events. Ainsworth (1963), in a study of Ganda infants, reported that from the sixth month infants vocalized more readily and more frequently when interacting with their mother than when they were in interaction with other persons. As Ainsworth points out, differential vocalization is one of the means by which infancy attachment can be maintained through a middle distance. "The implication is that however important actual physical contact may be to the human infant, many of the components of attachment and much important interaction between the infant and a loved figure involve distance receptors rather than tactual and kinaesthetic modalities" (p. 102).

Modification of infants' vocal responsiveness through social reinforcement has been reported by Rheingold *et al.* (1959), who successfully utilized an operant-conditioning technique to increase the frequency of vocalizations among 3-month-old infants. A baseline level of response to a silent, expressionless face was established over sessions occurring on 2 successive days; during the subsequent conditioning period, the experimenter smiled, make three "tsk" sounds, and touched the infant's abdomen on most of the occasions on which he vocalized. The infants' responses increased in frequency during two reinforcement sessions, which occurred on the third and fourth days of the study. On the fifth and sixth days the experimenter behaved in precisely the same manner as she did on the first and second days. During this extinction period, there was a marked decrease in vocalizations and also an increase in the infants' emotional behavior, including vocalizations indicative of distress.

Rheingold *et al.* (1959) suggested that some part of the reinforcing stimulus could have acted as a social "releaser." This possibility was investigated by Weisberg (1963), who employed six groups of infants in an experimental design which also permitted a test of the relative effectiveness of a social and a nonsocial reinforcer. The presence of a nonresponding adult, social stimulation similar to that employed by Rheingold *et al.* but not contingent on the infants' vocalizing, and both contingent and noncontingent nonsocial stimulation (a door chime) all failed to produce a increase in infant vocalizations. In contrast, social stimulation contingent on the infants' vocalizing resulted in a marked increase in rate of responsiveness over a previously established baseline level. During two extinction sessions, in which the experimenter was present but nonresponsive, the socially reinforced infants' rates of vocalization decreased, though not to the baseline level.

In the Rheingold *et al.* and Weisberg studies, the social stimulus included

visual, auditory, and tactual elements. Further studies in which visual, auditory, and tactual stimuli are independently presented would be of value in determining the relative importance of stimulation mediated by the distance receptors and of physical-contact stimuli in modifying infant vocalizations. Moreover, investigations into the relative potency of social and nonsocial stimulation should attempt to control the complexity variable; a major defect of Weisberg's study is that his social stimulation involved three sense modalities, whereas he utilized a nonsocial stimulus that had auditory components only.

Vocalizations indicative of distress (crying, whimpering, and whining) occur immediately at birth and may be elicited by a variety of stimuli, including sudden, intense auditory or visual changes (Illingworth, 1955; G. G. Thompson, 1952). The fear response as delineated by J. B. Watson (1919), is elicited by sudden noises and loss of support, as well as by physically painful stimulation.

Kessen and Mandler (1961) have effectively criticized theories that present all infant distress as originating from a single archetypical event or class of events producing physical pain. They point out, for example, that the startle and distress responses of infants occur to stimuli that are not physically painful and that interruption of highly practiced and well-organized responses frequently provides an occasion for the expression of distress. The observation that human beings afflicted with congenital analgesia exhibit a normal development of anxiety to nonpainful events (Fanconi & Ferrazzini, 1957; West & Farber, 1960) affords particularly strong support for the viewpoint expressed by Kessen and Mandler. Further instances of eliciting of infant distress by nonpainful stimulation are provided in the studies by Brackbill (1958), Rheingold *et al.* (1959), and Schaffer and Emerson (1964a).

Kessen and Mandler (1961) make the suggestion that: "in addition to the classical mechanisms of escape and avoidance of danger, anxiety is brought under control (that is, diminished or removed) by the operation of *specific inhibitors*" (p. 400). These inhibitors, according to Kessen and Mandler, need have no relation to a specific state of discomfort, privation, or pain. The authors cite nonnutritive sucking (Kessen & Leutzendorf, 1963), physical contact with the mother (Harlow, 1958), rocking, and the sight of the adult face as possible congenital or early developed inhibitors of distress.

There is considerable evidence in favor of the view that the human face serves as an inhibitor of distress (e.g., Brackbill, 1958). Other visual and auditory stimuli also seem to have this capacity. There is, in fact, a possibility that any complex novel stimulus that is capable of eliciting smiles from infants can, under certain circumstances, act as a distress inhibitor (Salzen, 1963).[2] Perhaps most of the apparently congenital inhibitors of distress produce their

[2] B. L. White (1964) agrees with this point of view on the basis of some of his unpublished research findings. He considers, however, that the factor of familiarity is also involved.

effect through the eliciting of responses incompatible with crying and other manifestations of distress.

Evidence of the effectiveness of a very specific kind of auditory stimulation for reducing infant distress is provided by Salk (1962). Salk measured the weight change, food intake, amount of crying, and average time taken to fall asleep of 102 neonates who were exposed to a normal heartbeat sound, recorded on tape, and of a control group of 112 neonates under ordinary hospital conditions. The infants exposed to the heartbeat cried less and took a shorter time to fall asleep than the control infants. They also gained more weight over a 4-day period, in spite of the fact that the two groups of infants consumed approximately the same amount of food, a finding indicating that the experimental group probably exhibited less restless activity. Other sounds—a metronome set at 72 beats a minute and continuously recorded lullabies—were not effective in inducing sleep; moreover, when a gallop heart rate and a heartbeat of 128 beats a minute were introduced into the nursery, there was an immediate increase in the infants' crying and restlessness. Salk suggests that there is auditory imprinting to the mother's heartbeat in the human fetus during prenatal life. Whether or not Salk's suggestion receives further support, his initial findings definitely indicate the importance of some kinds of auditory stimulation for both inducing and reducing infant distress. Further evidence to this effect is provided by Weiss (1934), who found that infant activity, probably indicative of distress, was reduced through auditory stimulation by tones of 75 and 50 decibels, with the louder tone producing the greater reduction.

A study with monkeys, reported by Seay *et al.* (1962), has some relevance to the issue under discussion. The experimenters separated 6- to 7-month-old monkeys from their mothers for a 3-week period; the infants were placed in pairs in a cage with plexiglass sides through which they could see their mothers. The investigators reported that the infants showed increases in crying and in visual contacts with their mothers during separation and increases in clinging behavior when they were returned to them. The findings support Harlow's view that contact comfort is an important socialization variable, at least for monkeys. In the absence of a third experimental group of infants, not permitted visual contact with their mothers, it is impossible to tell whether the infants' distress was alleviated by permitting visual contact during the separation period. This possibility deserves exploration.

At the human level, Schaffer and Emerson (1964a) provide data concerning the relative potency of different kinds of social-interruption sequences for eliciting protest behavior at different ages. Changes in relative potency occurred in the course of the first 18 months of life. In the early months of life, interruption of physical contact was more likely to evoke protest than interruption of visual contact; after the first 6 months, interruption of visual contact

became increasingly important as an evoking stimulus. This shift in the relative potency of physical and visual contact may perhaps be attributed to an increase in the range of the infant's vision. Until vision is sufficiently developed for the form of more distant objects to be clearly perceived, separation events that commence at some distance from the infant and provide no auditory cues (for example, a mother's quietly leaving the room) can have no significance for the child.

In socializing their children, the majority of parents rely heavily on the production of distress. The view that has predominated in the child-training literature is that the effectiveness of "disciplinary" procedures derives from events that are associated with physical pain during the early stages of the child's life. Just as the alleviation of physical discomfort caused by hunger has been regarded as the crucial factor in establishing attachments, so the occurrence of physical pain in the absence of the parent has been presented as a crucial factor in the development of fears of abandonment and loss of love. An excellent example of this kind of theorizing is provided by Dollard and Miller (1950):

> "Let the child get very hungry when it is alone, let it cry and not be heard or attended to, but let the quantity of stimulation in its body from hunger and from crying continue to rise. When the child is finally fed, these very strong terminal responses are reinforced and can be attached to all the stimuli which were present during the period of its intense hunger. These responses can produce stimuli of drivelike strength. Similarly responses which produce strong drives can be attached to the darkness, to the immobility of objects, to quietness, to absence of parental stimuli. Once the child has inadvertently learned to fear darkness and quiteness and immobility, it will also learn to escape from the darkness into the light, from the quietness into noise, and from immobility into the presence of others" (pp. 133–134).

According to this theoretical orientation, the association of isolation with physical pain gives rise to fears that later enable parents to discipline their children through techniques that threaten withdrawal of supportive parental interaction. Since there are sources of distress other than physical pain, this theorizing is of doubtful validity. In presenting their critique of traditional accounts of the development of anxiety, Kessen and Mandler (1961) make the suggestion that the removal of specific inhibitors of distress or the threat of their removal may have a disinhibitory effect. The efficacy of many parental disciplinary maneuvers—isolation, threats of withdrawal of affection, ridicule, and deprivation of privileges, which often symbolize withdrawal of parental

approval and affection—may well be due to disinhibition of distress. Such procedures can be effectively used by parents who have never or very rarely physically punished their children; when these procedures have not been paired with the infliction of physical pain, their effectiveness cannot be attributed to a pain-signaling function.

In this section we have presented evidence that certain kinds of auditory and visual stimulation serve to quiet a distressed infant and that the interruption of such stimulation evokes distress reactions. The efficacy of many disciplinary techniques may therefore originate from the child's visual and auditory, as well as contact comfort, experiences and have little or nothing to do with experiences of physical pain. Physical punishment is not a preferred technique of discipline in most North American homes (Sears *et al.,* 1957); in fact, parents who physically punish infants in the first few months of life are generally regarded as "abnormal." Consequently, opportunities for the infant's associating parent-produced pain with threats of loss of parental affection and attention are extremely limited. On the other hand, opportunities abound for the association of parental threats implying withdrawal of physical, visual, and auditory contact (affection or love) with the actual withdrawal of contact. The threat may then serve to disinhibit anxiety or distress and initiate behavior designed to reinstate parental contact.

IV. Exploratory Behavior and Play Patterns

Investigations of the affectional systems and attachment behavior of human and monkey infants (e.g., Ainsworth, 1963; Harlow, 1960) have revealed that once a secure infant-mother attachment has been formed, the infant will use the mother as a base from which to explore its environment. A similar observation was made years ago by Arsenian (1943), who observed preschool children's reactions in a strange room in the mother's presence or absence. When left alone in the room, the children showed little exploratory activity, tending instead to remain in the vicinity of the door; in contrast, if the children were accompanied by their mother on the first session, they moved around the room and played freely with available toys.

The importance of exploratory locomotor behavior in the development of social responses is most clearly evident from research with infant monkeys (Harlow, 1963; Rowell, 1963). Harlow and his co-workers observed that infant monkeys raised on mother surrogates were markedly retarded, in comparison with normally raised infant monkeys, in the development of social-play patterns. Even greater retardation was found in infant monkeys reared together in the absence of a mother.

The form that early exploratory behavior of young organisms takes is neces-

sarily species-specific. In comparison to human neonates, newly born subhuman primates and mammals, such as dogs and cats, have relatively well developed manipulative and locomotor responses (Rheingold & Keene, 1965). Apart from the grasping reflex, the first prehensory responses of human infants occur some time after following responses to visual and auditory stimuli have made their appearance, and integrated reaching and grasping behavior appears only in the fifth to sixth months of life (White *et al.,* 1964). Contrast this with the prehensile development of the infant monkey who can, within the second week of life, approach and grasp other monkeys and cling to its mother without assistance, even when the latter is moving rapidly (Rowell, 1963).

Psychologists who have sought to trace the genesis of social responses in infancy have focused on the following response to a tactual stimulus—the turning of the neonate's head to make oral contact with an object placed against its cheek (Sears *et al.,* 1957). In contrast, relatively little weight has until recently been given to the tracking of a moving object or head-movement directed toward sources of sound, which has been observed to occur as early as the first day of life, provided that the infant is in a state of alert inactivity (Wolff, 1959). The infant's visual capacities, although developed to a greater extent in respect to form perception than has customarily been supposed (Fantz *et al.,* 1962), are admittedly restricted for the first few weeks of life (Haynes *et al.,* 1965; Frantz, 1965; White *et al.,* 1964); nevertheless, the early occurrence of head-turning responses to visual and auditory stimulation is probably of as much importance for later social development as is the sucking reflex. Certainly, the capacity for visual and auditory responses, however rudimentary, is present soon after birth in the form of the orienting reaction (Berlyne 1960; Lipsitt, 1963). This response, may, in fact, be the primary foundation for the infant's social development, since it is accompanied by modifications of attention that frequently bring the infant into contact with the social agents who, at the commencement of his life, provide him with most of his visual and auditory stimulation. These modifications of attention also seem to be the forerunners of responses that have been variously labeled as "curiosity" and "exploration," of which attention is an essential component (Dember & Earl, 1957).[3]

There is some evidence that the orienting response may have considerable strength very early in an infant's life. Bronshtein *et al.* (1958) reported that the nonnutritive sucking of neonates could be inhibited by a loud tone; however, this finding was not replicated in a subsequent study by Kaye and Levin (1963). Kasatkin and Levikova (1935) conditioned the sucking response of infants, 14 to 48 days old, to a colored light by pairing the light with a

[3] Wolff and White (1964) have recently demonstrated that 4- and 5-day-old normal infants are capable of visually pursuing a 7½-inch bright red circle through an arc of approximately 60 degrees.

bottle of milk; on the initial conditioning trials, the light stimulus evoked an orienting response, which required habituation before conditioning could proceed. Demonstrations that orienting responses to auditory and visual stimuli may, very early in a child's life, interrupt or suppress the sucking reflex present a challenge to theories of social development that depict the infant's behavior as controlled almost exclusively by internal stimulation.

Most of the following responses that an infant remains capable of making during the first few months of life consist of head and eye movements in response to visual or auditory stimulation. By means of these responses he is able to explore objects at a moderate distance for some months before he can approach them through locomotion, and he can thus establish and maintain contact with his social environment. Impressed by the manner in which an infant follows social objects, particularly the mother, with its eyes, Caldwell (1962) has suggested that the oculomotor following response of infants may be a human equivalent of the locomotor following response of "imprinted" birds.

The manner in which environmental factors may modify the development of visual exploratory behavior in very young infants is neatly demonstrated in a series of ongoing studies by B. L. White (1963). Institutionally reared infants who were provided with 20 minutes of daily handling over and above that received in normal caretaking situations showed, in comparison to control infants, accelerated development of visual exploratory activity. Infants who were provided with a very large amount of visual stimulation, in addition to handling, exhibited initial retardation of exploratory behavior; however, after several weeks of exposure to this extra stimulation, these infants' activity increased well beyond the point reached at the same age level by control infants and by those who had received only the additional handling. In addition, pilot data suggested that salient objects, placed at a distance designed to facilitate maximum attention from infants, would greatly accelerate the development of visually directed reaching. White's data strongly support the view that stimulation in general, provided that the amount is not excessive, facilitates the development of classes of responses that are undoubtedly important for later social development.

Even when locomotor skills have been developed, the infant's exploratory behavior is stimulated and guided by input through the distance receptors. In addition, the development of adequate locomotor skills may be highly dependent on visual feedback from components of motion of the body (White *et al.*, 1964). Thus, visual and auditory stimuli are of primary importance in facilitating and maintaining locomotor exploratory activities, without which the infant's social interactions would be necessarily limited.

Moreover, an infants' contact with a mother or other familiar adult, who may serve as a secure base from which it may explore, may be maintained

primarily through vision and hearing. Schaffer and Emerson (1964b) compared a group of infants who resisted any form of physical contact involving restraint ("noncuddlers") with infants who actively sought out physical contact ("cuddlers"). Both groups of infants used their mothers as "a haven of safety" during exploratory activities, but the groups differed in their typical mode of response to fright. Noncuddlers, rather than seeking close contact with the mother, established proximity by looking away from the frightening object and turning toward the mother or made only limited physical contact through holding the mother's skirt or hiding their faces against her knee. There may well be constitutional or early established differences among infants that are reflected in the extent to which their social attachments are developed and maintained by distance-receptor stimulation. For some restless, hyperactive infants, contact is apparently not comforting (Schaffer & Emerson, 1964b); these infants may develop attachment behavior primarily on the basis of distance-receptor stimulation, which may then suffice to maintain their contact with caretakers during early exploratory activities.

Whereas Schaffer and Emerson seem to emphasize constitutional factors as a basis for individual differences among infants in the extent to which physical contact is sought during exploratory activity or play, Kagan and Lewis (1964) place more weight on the role of early experiences involving maternal reinforcement of infants' physical-contact behavior. Kagan and Lewis observed the behavior of 13-month-old children in a free-play situation in the presence of their mothers; following the free-play session, the children were frustrated by being separated by a barrier from their mothers and from previously accessible toys. Children who frequently made physical contact with their mothers during play also tended to exhibit distress when frustrated: this pattern of behavior was much more characteristic of girls than of boys. Parent data indicated that mothers of these "high-touch, high-cry" children had tended to employ child-training practices involving close physical contact between mother and child. However, the precise significance of the data is difficult to determine since, according to Lewis (1964), mothers who provided much physical contact and reinforced touching behavior also tended to provide frequent distance-receptor stimulation. Like many recent multi-variable studies bearing on the development of social responses in infancy and early childhood, the Kagan and Lewis experiments require and merit replication with improved dependent measures and additional controls.

Some evidence has been provided by Rheingold (1963) that exploratory responses in infants as young as 3 months may be reinforced by visual and auditory feedback. Infants placed in a specially designed crib (Rheingold *et al.*, 1962) were able to touch a ball that, by means of an electrical circuit, activated brief motion-picture sequences, accompanied by music. When the appearance of a motion-picture sequence was contingent on the infants' touching

the ball, rates of ball-touching were higher than those obtained when presentations of the visual and auditory stimuli were not contingent on the infants' responses. Preliminary investigations appeared to indicate that exploratory behavior may be strengthened merely through the visual and auditory experiences that this behavior produces, but that the behavior is more adequately maintained when the sensory feedback is complex and varied than when the stimuli presented are relatively simple and unvarying. Further data in support of the view that infants' exploratory and operant play responses can be shaped by perceptual reinforcement produced by the infants' own activities are provided by Friedlander (1964) and Friedlander and Kessler (1964). Comparable findings were obtained in Butler's (1954, 1958) studies on the exploratory behavior of monkeys.

Reports of controlled observations on the social development of blind, deaf, and deaf-blind infants, whose exploratory activities are necessarily curtailed, are conspicuously lacking in the literature on physically handicapped children. Nevertheless, it is generally agreed that defects of vision and hearing are associated with social retardation (Gesell & Amatruda, 1941). Careful comparisons of the development of infants with visual and auditory defects with that of infants with normal vision and hearing could throw considerable light on the role of the distance receptors in social development. Admittedly, there are methodological difficulties, including that of early diagnosis (J. Thompson, 1941); nevertheless, comparative studies of this kind would be worth-while projects.[4]

V. Imitative Behavior

The tendency for a person to reproduce, with a greater or lesser degree of exactness, the actions, attitudes, or emotional responses of others has generally been labeled "imitation" by experimental psychologists and "identification" in theories of social and personality development. However, the various distinctions between "imitation" and "identification" that have been proposed by social scientists (e.g., Mowrer, 1950; Parsons, 1951) are of little theoretical or practical value since both concepts refer essentially to the same behavioral phenomena (Bandura & Walters, 1963). The importance of imitation for the topic under discussion lies in the undeniable fact that it is almost always mediated by the distance receptors.

According to Freudian theory (Freud 1925, originally published in 1914), the relationship between a child and the person who cares for, feeds, and

[4] Ongoing research, recently reported by R. A. Scott (1964), confirms the view that congenitally blind children tend to be socially retarded. Such children, according to Scott, display little social interaction and tend to engage in autoerotic activities involving self-stimulation. In Scott's terminology, borrowed from Mead (1934), these children fail to develop realistic "I-thou" relationships.

protects him ("anaclitic object choice") provides the foundation both for the development of imitative behavior and for the establishment of subsequent social-emotional attachments. This point of view, which has greatly influenced learning-theory approaches to the problem of imitation (e.g., Mowrer, 1950, 1960; Sears, 1957; Whiting & Child 1953), ignores the possibility that the occurrence of imitative behavior may precede the formation of specific attachments and may therefore itself contribute to the development of a child's responsiveness to others.

There is considerable dispute concerning the age at which imitative responses first appear in a child's repertory. To a large extent, the issue is a semantic one, with proponents of apparently opposed views using different criteria for labeling a response as imitative. Shirley (1933), for example, reported an almost complete absence of imitative behavior among a group of 15 infants, 54 to 74 weeks of age, when the criterion of imitation was the exact copying of complex manipulative or verbal behavior. Such a criterion is, however, far too stringent; precise and detailed copying of a model is the exception rather than the rule even among older children and adults (Koffka, 1924). Moreover, the development of imitative behavior is probably a continuous process in which the simpler approximate reproductions, observable in infants, are the precursors of the more exact copying that is characteristic of early childhood.

Detailed data on imitative behavior in early infancy are largely limited to records of observations on individual infants, often secured by professionally interested parents and usually focused on the imitation of adult speech (e.g., M. M. Lewis, 1936; Stern & Stern, 1928; Piaget, 1951; Valentine, 1930). In the absence of adequate normative data on a wide range of responses, these observations can provide only a rough indication of the times at which imitative behavior first makes its appearance.

According to Piaget (1951), the earliest precursor of imitation, the cry of a child in response to another child's cry, may occur in the first few days of an infant's life. However, the crying of another infant rapidly becomes ineffective as an eliciting stimulus (Bühler & Hetzer, 1928), and it thus seems probable that Piaget is mistaken in regarding crying in response to a cry as anything more than a distress reaction to a loud sound.[5] On the other hand, there is considerable evidence that infants will reproduce a variety of adult responses, at least in an approximate manner, well before attachment behavior is apparent. Zazzo (1956, 1957) has provided records (some filmed) of imitative tongue protrusions among infants less than 1 month of age,

[5] J. B. Watson (1924) strongly repudiates the view that the sound of an infant's crying will elicit crying from another child. The majority of writers, however, appear to disagree with Watson. Possibly there are individual differences among infants in respect to sensitivity to sounds, and disagreements arise from sampling limitations.

and several observers have noted the occurrence of imitative vocalizations and mouth and hand movements well within the first half year of an infant's life (e.g., Church, 1961; Piaget, 1951; Stern & Stern, 1928). While many of these investigators (e.g., M. M. Lewis, 1936; Piaget, 1951) agree that this early imitative behavior occurs only if the response is already in the child's repertory and the adult imitates the child first, this limitation does not reduce the significance of the behavior for early social development.

The social significance of the imitative responses of early infancy resides largely in their capacity for fostering adult-child interactions. Piaget's description (1951,p. 19) of an interaction sequence between his daughter and her mother provides an excellent illustration of this function:

> "At 0:6 (25) J. invented a new sound by putting her tongue between her teeth. It was something like *pfs*. Her mother then made the same sound. J. was delighted and laughed as she repeated it in her turn. Then came a long period of mutual imitation. J. said *pfs*, her mother imitated her, and J. watched her without moving her lips. Then, when her mother stopped, J. began again, and so it went on."

J's imitative behavior evidently served to prolong and intensify the visual and auditory stimulation which her mother was providing. If Schaffer and Emerson (1964a) are correct in their claim that stimulation of this kind is of paramount importance for the development of social attachments, the infant's capacity for approximate reproduction of adult responses assumes theoretical significance as a child-initiated contribution to the attachment process. As Church (1961, p. 34) points out, "imitation early becomes a vehicle of playful communication between child and adult."

The available data on imitation in early infancy, although admittedly scanty, suggest that the infant's capacity to reproduce actions and sounds made by others manifests itself some time before specific attachments are formed. Moreover, the infant's imitative responses may prolong adult-child interactions and thus facilitate the development of attachment behavior. Since mutual-interaction sequences involving imitation are, especially in the first months of a child's life, largely, if not entirely, mediated by vision and hearing, the data provide additional evidence for the importance of the role of the distance receptors in the development of social responsiveness.

VI. Related Theoretical Problems

A. Arousal and Attention

In the preceding sections it has been suggested that the infant's attentiveness to socially significant stimuli may have its origin in the orienting reaction

and may be facilitated by the complexity and constantly changing characteristics of the stimulation provided by the faces and voices of human caretakers. The orientation reaction is accompanied both by changes in arousal level and by modifications of attention (Berlyne, 1960, 1963); moreover, there is evidence from studies with animals, children, and human adults that changes in arousal influence cue utilization and perceptual organization (Bruner *et al.*, 1955; Easterbrook, 1959; Kausler & Trapp, 1960; Smock, 1962). The relationships between arousal, attention, and social responsiveness are undoubtedly complex and at the present time not well understood. However, the classes of infant responses that have been discussed in this paper—smiling, vocalizations, exploration, and imitation, as well as attending responses—have all been linked in one way or another with variations in arousal. Some brief comments on research on arousal and attention are consequently in order.

One of the few well-established facts relevant to arousal responses in infants is that there are marked individual differences in autonomic reactivity and related behavioral indices, for example, activity level and crying, even among neonates (Aldrich *et al.*, 1945; Grossman & Greenberg, 1957; Kessen *et al.*, 1961; Richmond & Lipton, 1959; Wolff, 1959), and that these differences are relatively stable, certainly over the first few months of life (e.g., Lipton & Steinschneider, 1964; Thomas *et al.*, 1960; Schaffer & Emerson, 1964a). One may speculate that individual differences in reactivity influence the extent to which attention is paid to socially relevant stimuli and consequently the rapidity with which attachment behavior develops. This suggestion is consonant with research findings on older subjects (summarized by Bandura and Walters, 1963, pp. 200–203), indicating that emotional lability facilitates social learning, a process that can be achieved only if attention is given to the responses of other persons (Walters & Parke, 1964).

Many observers have commented on the increased salience of attachment behavior when infants are physically or perceptually separated from a familiar adult. In fact, Schaffer and Emerson (1964a) employed various indices of "separation upset" as measures of attachment formation. The protest responses recorded by the investigators, varying from whimpering and lip trembling to loud consistent crying, may perhaps result from the disinhibition of "primitive" distress responses (Kessen & Mandler, 1961) that tend to terminate when a person is seen or heard by the child. Protest responses, as Salzen (1963) has noted, may also be alleviated by complex, varying, nonhuman stimuli that can capture and arrest the attention of a child. It thus seems that the withdrawal of certain kinds of external stimulation may be associated with heightened arousal (cf. Amsel, 1958; Lawrence & Festinger, 1962), while the provision or reinstatement of external stimulation may, under some circumstances, have a quieting effect, which is often reflected in a smile. Smiling and protest may, in fact, be conceptualized as responses that are linked with

different arousal levels (cf. Brackbill, 1958). Generally speaking, social smiling accompanies the focusing of attention on some environmental object and a lessening of general activity, whereas protest behavior, at least during early infancy, is characterized by diffuse, restless activity, as well as by crying, and a lack of prolonged attention to any single environmental event.

According to Wolff (1963), smiling becomes socially significant only when the response has acquired a certain degree of autonomy from variations in arousal state. By this, Wolff means that the smiling must occur when the infant is awake and "bright-eyed" and not when it is drowsy or in a light sleep. The sense in which Wolff employs the term "arousal" is, however, different from that which it has acquired in the writings of psychologists such as Berlyne (1960), Hebb (1955), Lindsley (1951), and Malmo (1959), whose interests have focused on the functioning of the reticular activating system. According to these latter writers, an organism's level of arousal *increases* as the organism changes from a drowsy state to one of alertness. Wolff's observations appear, therefore, to indicate not that social smiling is independent of the infant's arousal state, as this concept is generally employed, but that the infant must be in a sufficiently aroused state to attend selectively to environmental stimuli. The conclusion that may be drawn, on the basis of observations of smiling and protest behavior, is that positive social responses are most likely to occur when an infant's arousal level is within a moderate range that permits the focusing of attention on objects in its environment.

Kagan and Lewis (1964) reported positive relationships between fixation times and cardiac deceleration for highly attentive 6-month-old infants, i.e., those with long fixation times, but no relationship between these variables for infants who were minimally attentive. These findings suggest that infants who are most responsive to auditory and visual stimuli also display parasympathetic effects which may have reinforcing properties (cf. Malmo, 1961). The direction of any cause-and-effect relationships that may be involved are far from clear; the Kagan and Lewis findings nevertheless suggest that a relatively high degree of attention to visual and auditory stimuli is accompanied, and perhaps sustained, by modifications of neurophysiological states.

The relationships between arousal level and exploratory behavior or stimulus seeking has been discussed by a number of psychologists (e.g., Berlyne, 1960, 1963; Fiske & Maddi, 1961; Hebb, 1955; Hebb & Thompson, 1954; Hunt, 1963; Leuba, 1955, 1962; Smock & Holt, 1962). Although the relevant theories differ considerably in detail, all attempt to identify some optimal condition, either of arousal or of stimulus input or patterning, which the organism strives to maintain. Among infants, exploration seems to occur most readily when the infant is alert and active, but not overwhelmed by a large amount of intense novel stimulation (B. L. White, 1964); "no observant parent will question the fact that babies often act in this way [i.e., manipulate and per-

ceptually explore objects] during those periods of their waking life when hunger, erotic needs, distresses, and anxiety seem to be exerting no particular pressure" (R. W. White, 1959, p. 320).

Any detailed discussion of theoretical approaches to the problems of "intrinsic motivation" and of the relationship between arousal level, external stimulus properties generating arousal changes or conflict, and modifications of attention cannot be undertaken within the context of the topic of this paper. It may, however, be tentatively concluded that observations of infants are consistent with the view that perceptual functioning, including the functioning of the distance receptors, is facilitated by a moderate degree of emotional arousal and that stimulation provided by the distance receptors is, in some way, rewarding for the infant. Most of the infant's visual and auditory stimulation initially occurs within the context of social-interaction sequences; consequently, evidence that there are important interactions between stimulation through the distance receptors and emotional-arousal states tangentially supports the view that this kind of stimulation can play a critical role in the development of human attachments.

B. Imprinting and the Critical-Period Hypothesis

Several investigators (e.g., Ambrose, 1963; Bowlby, 1958; Caldwell, 1962; Gray, 1958; Scott, 1963) have been impressed by apparent similarities between "imprinting" phenomena in precocial birds and the formation of attachments by human infants. Gray (1958) defined imprinting as "an innate disposition to learn the parent, or parent-surrogate, at a certain early period in life" (p. 156) and proposed that "the smiling response in human infants is the motor equivalent of the following response in animals below the higher primates" (p. 160). Caldwell (1962) offered the alternative proposal that the visual following response is the human equivalent of the locomotor following response of birds, while Salk (1962) has suggested that the human fetus is imprinted to its mother's heartbeat. A somewhat different point of view, mainly based on studies of the attachment behavior of dogs, is expressed by Scott (1963), who holds that, during a critical early period of development, a young animal will become attached to any animal or object with which it comes into long contact.

The value of attempting to identify parallels between specific responses of human infants to other members of its species and imprinting phenomena in birds is highly questionable. Nevertheless, the observation that imprinting in ducks normally occurs before feeding takes place has lent strength to the view that attachment behavior is not necessarily generated within the context of the feeding situation. Support for this view also comes from an experiment

by Fuller [cited by Scott (1963)], who demonstrated that dogs who had contact with a human being but were otherwise socially isolated became attached to this person even though he was not associated with the feeding situation. Perhaps even more significant is Fisher's (1955) finding that puppies display attachment to a human with whom they have only painful physical interaction if no other social contact is available to them. Studies with animals provide evidence, then, that birds and dogs form attachments that neither originate in a hunger-reduction context nor are mediated by contact-comfort experiences. It therefore seems safe to conclude that stimulation through the distance receptors—through vision, hearing, and possibly, in the case of dogs, through smell[6]—may be a sufficient basis for the development of attachment behavior in some subhuman species. In view of the rapid development in human infants of distance-receptor functioning and the importance of these receptors for later human behavior, there is little reason to doubt that early distance-receptor experience may not sometimes also suffice for the development of human attachment behavior.[7]

Research on precocial birds and dogs has led to the theory that there is a relatively short period early in life which is critical for the development of attachment or filiative behavior. Caldwell (1962) has distinguished two, not necessarily unrelated, aspects of this critical-period hypothesis: (*a*) There is a critical period *beyond* which attachment behavior will not develop; and (*b*) there is a critical period *during* which an organism is maximally susceptible to influences that promote attachment behavior. While the first of these aspects has received considerable attention and support in studies of subhuman species (e.g., Scott, 1958), it has received relatively little attention in discussions of the formation of attachments by human infants, among whom there are remarkable individual differences in respect to the time at which specific attachments first appear (Schaffer & Emerson, 1964a). Applications of the critical-period hypothesis to human infants have, in fact, focused on the relative harmfulness of *disruptions* of infant-caretaker relationships at different stages of infant development. "The present evidence indicates that while the period of 6 weeks to 6 months is a critical one for the formation and determination

[6] The important role of olfactory stimuli in the genesis of attachment behavior in kittens has been noted by Schneirla and Rosenblatt (1961).

[7] Cairns (1964) has now provided evidence in favor of the view that an animal will develop a relative preference for any perceptually prominent object with which it has been continuously brought into proximity. Lambs confined with canines showed increasing preference for their cohabitants, as opposed to members of their own species, over a nine-week period. A similar, though less marked, increase in preference for the cohabitant was demonstrated for lambs confined with a continuously operating television set. In a later phase of the study, lambs failed to develop preferences for a nonoperative, perceptually dead, television set.

of social relationships, the later ages are also *critical* with regard to psychological damage resulting from breaking off these relationships" (Scott, 1963, p. 34; italics not in original). In this context, the term "critical" appears to lose much of the apparent significance with which it has been endowed by research findings on critical periods in subhuman species.

Obviously, the disruption of a specific attachment can have no particular significance until a specific attachment has been formed. Evidence that infants under 6 months of age are not greatly disturbed by separation from their mothers, whereas older infants show much more disturbance (Yarrow, 1964), provides support of the hypothesis that most infants do not develop specific attachments until the second half of the first year of life but does not have a crucial bearing on the critical-period hypothesis. Moreover, the data provided by Schaffer and Emerson (1964a) more directly support the former hypothesis than do clinical observations on reactions to "traumatic" separation events. The severity of a reaction to a disruption of an established affectional relationship, at any stage of life, is probably a function of the deprived person's competence to seek out and secure alternative sources of rewarding experiences. In this respect, infants are probably little less handicapped than elderly persons, for whom separation may also have both acute and relatively long-term deleterious effects (Birren, 1964).

Admittedly, there is considerable evidence that the age of an infant when separation occurs and the duration of the separation period are highly significant variables in relation to both the immediate effects of the disruption of the relationship and its long-term effects on the child's social-emotional development (e.g., Bowlby, 1952; Goldfarb, 1943, 1945a,b, 1947, 1955; Lowrey, 1940; Schaffer, 1958; Schaffer & Callendar, 1959; Spitz, 1945, 1946a; Yarrow, 1961, 1964; Yarrow & Goodman, 1963). However, this evidence in no way demonstrates that disruption of a caretaker-child relationship at a particular stage of development *inevitably* proves detrimental to the infant's subsequent social adjustment. In fact, research findings indicate that the effects of separation are highly dependent on the infant's experiences during and following the separation period (Yarrow, 1964) and can, under some circumstances, have long-term beneficial effects (H. Lewis, 1954).

While the critical-period hypothesis appears to receive little support from research on human infants, it seems possible that there are *events* that are critical for the development of human social behavior (Caldwell, 1962). Under the influence of Freudian theory, clinically oriented research workers have sometimes assumed that these critical events are biologically based concomitants of "mothering" (e.g., Ribble, 1943). The alternative view, favored in this paper, is that the events in question are not intrinsically related to the nurturant activities of a need-reducing, comfort-producing adult, but rather

consist of frequent associations of the infant's own species with exteroceptive stimulation. From this latter point of view, perceptual-cognitive development, largely fostered by exteroceptive stimulation, is essential for social development; attachment behavior occurs because certain individuals, usually of the same species as the infant, are associated more often than others with the perceptual-cognitive stimulation provided by environmental events. This point of view is not purely speculative; it is supported by the evidence provided in previous sections of this paper as well as by some of the findings concerning the effects of separation and institutionalization, cited below.

After a thorough, careful review of studies of the effect of separation from parents in early childhood, Yarrow (1964) concluded that many of the apparently harmful effects of separation experiences can be attributed to general deprivation of stimulation—sensory, social, and affective—which characterizes many institutional environments, rather than to the disruption of a specific parent-infant relationship. If some consistency in caretakers and a reasonably stimulating environment are provided, institutional living does not appear seriously to hamper the social development of children (e.g., Freud & Burlingham, 1944; Rheingold, 1961). Three studies, in particular, seem to confirm the importance of exteroceptive stimulation, particularly through vision and hearing.

In a classic study, Dennis (1941) and his wife reared twins under conditions of minimal stimulation, avoiding the customary affectional interactions that occur between caretakers and child. In spite of the experimenters' avoidance of fondling and other social responses directed toward the children, the twins exhibited no social-emotional retardation. Judging from Dennis' description of the procedures, it seems reasonable to assume that the infants received a considerable amount of exteroceptive stimulation both during observation periods and while routine caretaking activities were being carried out in an "impersonal" manner. The experimenters talked within the hearing of the infants, even if they did not talk to them; they spent a good deal of time within sight of the infants while recording the infants' behavior. In fact, they may have provided as much distance-receptor stimulation for the infants as do many natural parents. From the point of view expressed in this paper, the Dennises' findings are therefore less paradoxical and puzzling than they have appeared to be to some psychologists who have not favored the maturational interpretation advanced in the report of the study.

Rheingold (1961) compared the social responsiveness and exploratory behavior of institutionalized infants of 3 to 4 months of age with those of home-reared infants of the same age. Contrary to expectations, she found that the institution infants were more socially responsive to the examiner than the home-reared infants and that they were in no way deficient in their exploratory responses. Rheingold was led to the conclusion that the institution provided

sufficient stimulation in general to evoke visual exploration of the environment, which, she suggested, formed the basis of human sociability.

Schaffer (1963) has provided a preliminary report of a comparative study of two groups of infants temporarily separated from their mothers. One group, the hospital group, had regular contact with their mothers but received little total stimulation, social or otherwise, during the separation period. The second group, the baby-home group, had no contact with their mothers during separation but received a considerable amount of social and other stimulation. On their return home, the baby-home infants established specific attachments to their mothers much more rapidly than infants in the hospital group. "In the Hospital group all but one infant took at least four weeks to establish a specific attachment, two took approximately three months to do so, and one infant had still not shown any specific attachment behavior by the time he reached the end of the first year. In the Baby-Home group, on the other hand, five of the nine infants developed a specific attachment within five days of returning home and two others did so within the second week . . . These data suggest that a prolonged acquaintance with the individual(s) with whom a specific attachment is eventually formed is less essential than the total amount of prior social stimulation received by the infant, irrespective of the source" (p. 191). Schaffer concluded by offering the hypothesis that attachment behavior is a three-stage process: ". . . an early phase in which optimal arousal is sought from all parts of the environment precedes a phase where the infant, having learned that social objects provide the best sources of such stimulation, shows indiscriminate attachment behavior to all human beings, and this finally gives way to the phase with which we are best acquainted, namely the phase of specific attachments" (p. 196).

The previous discussion has omitted consideration of an important phenomenon of human behavior—the appearance of fear of strangers, which has sometimes been regarded as the homologue of the flight response of many subhuman species (e.g., Freedman, 1961). In what sense, it may be asked, is this a critical event in the genesis of attachment behavior? Gray (1958) has suggested that the emergence of fear of strangers marks the end of the critical period during which attachment behavior must be established, if it is to be established at all. Some support for this view has been found in Moltz's (1960, 1963) discussions of the mechanisms of imprinting in ducklings.

According to Moltz, attachment to an imprinting object occurs in precocial birds because modifications in sensory input accompanying the approach response are associated with a parasympathetically governed organic set. The approach response is thus incompatible with sympathetically governed anxiety or fear states. Once fear has been acquired through a recognition of the distinction between familiar and strange aspects of the environment (cf. Hebb, 1946), the approach response is maintained because it is accompanied by anxiety reduction.

Establishment of an approach response therefore occurs during an early critical period in which the imprinting object is salient and other subsequently strange aspects of the imprinting situation are not yet noticed.[8]

Data on human infants (Schaffer & Emerson, 1964a) indicate that, generally speaking, specific attachments are evident before fear of strangers is manifested. Moreover, it is common knowledge that human infants will often exhibit intensified attachment behavior when first confronted by a strange person or environment. However, human caretakers differ in the extent to which they reduce or induce anxiety in the course of their interactions with infants (Ambrose, 1963). If the principal caretaker frequently induces anxiety in the infant, this anxiety may generalize to other individuals in the early months of an infant's life; in this case, generalized anxiety may have to be extinguished before attachment behavior that is maintained by anxiety reduction can occur. Under such circumstances, prolonged attachments to a specific object may not be manifested until after the discrimination between familiar and strange has been achieved and fear of strangers has developed. Wide individual differences in the timing of the first appearance of specific attachments (Schaffer & Emerson, 1964a) seem to support the view that the achievement of familiar-strange discriminations does not preclude the emergence of an initial specific attachment.

Extensions to the attachment behavior of human infants of theorizing concerning imprinting and the critical-period hypothesis have raised more problems than they have solved. The identification of analogies can suggest useful cause-effect hypotheses only if differences, as well as similarities, between phenomena are taken into account. However, analogical thinking concerning imprinting phenomena and the formation of human attachments has at least encouraged some developmental psychologists to break away from traditional lines of thinking concerning the origins of social responsiveness and has helped to focus attention on the possible role of distance-receptor stimulation in the genesis and maintenance of human social behavior.

VII. A Comment on Dependency

In this discussion of the development of human sociability, we have substituted the term "attachment" for the concept of dependency, which has been generally favored in the child-training literature (e.g., Bandura & Walters, 1959, 1963; Child, 1954; Sears *et al*, 1957; Whiting & Child, 1953). In the first place, as we have argued elsewhere (Walters & Parke, 1964), "dependency" has functioned as a semi-evaluative, rather than a descriptive, concept

[8] Moltz's theorizing has, of course, important implications for the relationship between arousal and attention, which was discussed in the previous section.

and will therefore probably prove to be of little ultimate value in conceptualizing social phenomena. Secondly, we agree with Bowlby (1958) that to be dependent on someone and to be attached to someone are not the same thing. "The terms 'dependence' and 'dependency' are appropriate if we favour the theory of Secondary Drive, which has it that the child becomes oriented towards his mother because he is dependent on her as the source of physiological gratification. They are, however, inappropriate terms if we believe that dependence on physiological satisfactions and psychological attachment, although related to one another, are fundamentally different phenomena" (p. 371).

Much effort has been devoted to accounting for the manner in which a child gives up its physical dependence on its mother and substitutes interactions largely mediated by the distance receptors for the clinging, physical-contact "dependency" responses of infancy and early-childhood years. We maintain that attention and approval seeking are not entirely derivates of early physical-dependency gratifications but are habits that are developed from the beginning of life in the course of the infant's perceptual transactions with its environment, most of which involve visual and auditory stimulation. In this connection, it is interesting to note that Sears (1963) has recently provided some evidence in favor of a two-factor theory of dependency, which suggests that physical-contact behavior develops relatively independently of responses such as attention and approval seeking. One may speculate that whereas positive and negative reinforcement, as well as modeling (Bandura & Walters, 1963), of physical-contact responses may be highly important in the formation of later patterns of sex behavior, the formation of psychological attachments is primarily fostered by distance-receptor experiences. Certainly, in later life the majority of social attachments are developed and maintained in the context of visual and auditory interactions and are accompanied by relatively little physical-contact stimulation.

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SOCIAL REINFORCEMENT OF CHILDREN'S BEHAVIOR

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Adult approval is one of the most commonly used means of effecting behavioral change in children. From the period of mid-infancy the responses of parents and other significant adults form the referent which the child utilizes in ascertaining whether his behavior is permissible, satisfactory, or commendable. Since adult approval is more frequently expressed by a nod, smile, or "that's fine," than in the presentation of tangible reinforcement, the social aspects of adult approval constitute the most common source of reinforcement for most children.

Despite its importance, child psychologists have been relatively late in beginning a systematic investigation of the variables which decrease or enhance the effectiveness of social reinforcement in modifying children's behavior. Most of the studies have been published since 1958, but with only 5 years of research it is clear that social reinforcement is an extraordinarily complex form of reinforcement and that we have only a very primitive comprehension of its operation.

The purpose of this chapter is to attempt to organize the available data and to point out some of the more significant questions that still await answers. It is an entangled maze which must be traversed. Many variables, singly and in interaction, determine whether supportive comments from an adult will be greatly or only modestly effective. It is no surprise that it has been necessary to utilize a high degree of control over the situation in order to bring the role of these variables into view. Consequently, all the studies have been laboratory studies utilizing simple tasks over short periods of time. This, of course, restricts the degree to which the results can be generalized to the real-life situation, where both simple and complex tasks of both short and very long duration are performed. Some day the studies may be translated into real-life settings and indeed, Baer, Harris, and Wolf (1963) recently have demonstrated how nursery school children's behavior may be modified by a program of social reinforcement from their teachers. For now, however, our attention must be focussed primarily on the results from laboratory studies.

I. The Experimental Tasks

A. Selection of the Task

The first problem facing the experimenter is to select a task which will be sensitive to the effects of the variables which he wishes to assess. For a study involving social reinforcement the following factors are important in determining what will be an appropriate task:

1. The task must not possess high intrinsic interest if the effects of social reinforcement are to be maximized. If interesting tasks are used it is likely that the adult's supportive comments will initially have only a minimal effect and

will gain in effectiveness only after the child has played with the materials long enough to become satiated.

2. The task should not have a clear terminus or a visible product. Studies (i.e., Ovsiankina, 1928) have indicated that children will persist in tasks, apparently with only the motivation of seeing the task completed. Thus, attaining a particular goal or producing a visible object may be intrinsically motivating and the child may be little affected by an adult's response.

3. The tasks should minimize the effects of earlier learning. Individual differences among children often operate to obscure the effects of the variables under study and are enhanced if children enter a task with differences in skill or knowledge derived from earlier experience with similar tasks.

4. The task should permit the adult to dispense supportive comments arbitrarily. If the child has a clear idea of what constitutes satisfactory performance, or if there is a model who defines satisfactory performance, the discrepancy between the child's possibly insufficient or unsatisfactory performance and the adult's positive evaluation of the performance provides a source of difficulty in interpreting the results of the study.

5. The task should utilize discrete responses. Reliable measurement is more easily attained if responses can be counted, rather than scored or rated.

It is difficult to find or to construct tasks which avoid these problems. One task that apparently does, for it has been adopted by a number of investigators (Cushing, 1929; Wolf, 1938; Gewirtz & Baer, 1958a; Zigler *et al.*, 1958) and used in one form or another in most of the studies to be considered, is a simple marble-dropping task. This task employs a bin or delivery device which provides an apparently inexhaustible source of marbles and a box containing holes into which the marbles must be sorted. The child is told to put the marbles into particular holes (marble-sorting tasks), or, in some cases, into any hole (marble-dropping tasks). The experimenter then makes a series of predetermined supportive comments, either while the child is responding or following "correct" responses only. The increase in number of correct responses, the amount of time *S* will spend in the task, or the increase in rate of response have been used as measures of the effectiveness of social reinforcement.

The task in itself is quite dull, apparently endless, requires minimal prior learning, has no clear criteria for adequate performance, and uses discrete responses.

B. Reliability of the Task

There are few data related to the reliability of this type of task, but they are for the most part encouraging. Stevenson and Knights (1962a) correlated a base rate of response (number of marbles inserted during the first minute of the task prior to the introduction of social reinforcement) for institutionalized

retarded children with base rates obtained 12, 18, and 30 weeks later. The correlations were .74, .86, and .66. All were highly significant statistically, and, indeed, the *r's* are remarkably high for 1-minute samples of behavior.

For the form of the task involving the designation of one of two holes as "correct," Patterson, Littman, and Hinsey (1963) report a test-retest reliability of .70 for an increase-in-rate score when the same children were reinforced by the same experimenter in two sessions separated by 1 week. A measure of change in preference (increase in relative frequency of the least preferred response following the introduction of reinforcement of this response) showed a test-retest reliability of .75.

C. Intratask Comparisons

The average rate of response during the first minute correlates very highly with the rate of response on the successive 5 or 6 minutes of the task (Stevenson & Fahel, 1961; Zigler, 1963). The average r obtained with six independent groups in these studies is approximately .86.

Data concerning the relationship between the child's rate of response and his increase in rate of response following the introduction of social reinforcement are conflicting. Stevenson and Fahel (1961) report consistent negative correlations, varying between —.31 and —.41 ($p < .05$) for four groups of normal and retarded children, and Stevenson (1961) reports a correlation of —.40 between these measures for a group of 504 normal children. Zigler (1963), on the other hand, finds insignificant correlations of —.02 and —.08 for two groups of institutionalized and noninstitutionalized normal and retarded children. More data are needed, since the relationship between the child's initial rate of response and the change in rate of response is potentially important in determining the appropriate interpretation of experimental results.

Zigler (1963) has presented intercorrelations of various measures that have been used to assess the effectiveness of social reinforcement. Unless the different measures are significantly related to each other, it is impossible, of course, to compare the results of various studies. For noninstitutionalized normal and retarded children, the average increment in response following the introduction of social reinforcement correlates .62 ($p < .001$) with the total amount of time the child is willing to spend in the task. Surprisingly, however, when the same comparison is made for data obtained with normal and retarded institutionalized children the r drops to an insignificant .17.

Increase in rate of response is not correlated significantly with changes in preference when responses to one of two holes are reinforced following a base rate period. Patterson *et al.* (1963) report a correlation of .04 between these

two measures, thus indicating that the two measures appear to provide independent assessments of the effects of social reinforcement.

Since investigators have not adopted a standard form of the task or common measures of response, these preliminary data indicate that comparisons across studies can be made only if it is kept in mind that the results may be significantly influenced, not only by the variables investigated, but also by the measures of response employed.

II. Subject and Experimenter Variables

A. Sex of *S*

The differential effectiveness of social reinforcement, depending upon the sex of the child in relation to the sex of the experimenter, has been among the most interesting and consistent findings in the literature on social reinforcement. Gewirtz (1954), in a study of the determinants of attention-seeking in young children, was the first to give attention to this effect, although relevant data are available from earlier studies (e.g., Wolf, 1938). In Gewirtz' study, children, ranging in age from 4-0 to 5-7, painted in the presence of an adult who either attended completely to the child or was apparently engrossed in paper work. In the latter condition, girls made more bids for attention than did boys when the adult was a male, but boys made more bids for attention than did girls when the adult was a female. The ordering was replicated in a study by Gewirtz and Baer (1958a) of the effectiveness of social reinforcement following brief social deprivation. With the marble-sorting task, social reinforcement delivered by a male adult was found to be more effective in increasing the frequency of correct responses for girls than for boys. The order was reversed with a female adult.

The cross-sex effect was found in two subsequent studies. Stevenson (1961), using six- and seven-year-olds, found that the increment in rate of response following social reinforcement was greater for boys than for girls with a female adult, and greater for girls than for boys with a male adult. Stevenson and Knights (1962b) found comparable results with retarded children, whose mean CA was 14.7 years and MA was 8.5 years, and with normal children, whose mean CA was 8.4 years. Neither of the last two studies employed conditions involving the low availability or deprivation of social stimuli; thus these conditions are not necessary for the cross-sex effect to appear.

It is unlikely that the cross-sex effect is limited to the late preschool or early elementary school years. Even with college-age subjects women have higher rates of response in the marble-dropping task when social reinforcement is delivered by a male than when it is delivered by a female, and men have

higher rates when the reinforcement is delivered by a female (Stevenson & Allen, 1964). One of the studies cited above (Stevenson, 1961) also included nine- and ten-year-old children. At this age level the directions of the differences are in line with the cross-sex effect, although they are not statistically significant.

The cross-sex effect may be interpreted in a number of different ways, but perhaps the most meaningful focus about which to view the data is the Oedipal theory of Freud. This theory predicts a masculine object-choice for young girls and a feminine object-choice for young boys. The failure to find a disruption of the cross-sex effect with increasing age may simply reflect the incomplete resolution of the conflict. Another interpretation is possible. Social forces begin to operate after the first years to direct boys' activities toward those of other boys and men and to direct girls' activities toward those of other girls and women. This may result in deprivation of feminine support for boys and of masculine support for girls. Consequently, when such support is received its value may be enhanced, producing a greater effectiveness of adults of the opposite sex. The possibility must also be considered that the effect is not derived from characteristics of the children at all but from characteristics of adults. Adult males, for example, may "like" little girls better than little boys and demonstrate this in a warmer and more nurturant response to them than to little boys. Systematic observations of the behavior of the adults in the experimental task could determine the relevance of this interpretation. The whole topic is a tantalizing one and provides interesting opportunities for further analysis.

B. Characteristics of the Adult

It is obviously impossible within a particular study to make any generalizations about the cross-sex effect unless there is a sample of experimenters of each sex. The studies discussed above used from two to eight adults of each sex as experimenters. When the analysis of the results includes a consideration of the differences among experimenters, the rate of response of groups of subjects tested by different experimenters differs significantly, both during the base rate and reinforcement periods (Stevenson, 1961; Stevenson & Allen, 1963). The characteristics of the adults which produce such differences are elusive and do not appear to depend upon such potentially relevant factors as age, physical appearance, experience with children, or scores on personality tests. Since the differences in performance occur rather quickly, the characteristics must, however, be readily perceived by children.

It is doubtful that any particular set of characteristics will turn out to be of equal importance for all children. For example, a highly significant interaction between sex of subject, age of subject, and individual experimenter has been

found (Stevenson, 1961). Different women have a greater differential effect on the performance of children than different men, as reflected in a greater dispersion of mean responses for the groups of children tested by the various women. The dispersion increases with increasing age of *S*, thus reflecting the possibility that older children are more sensitive to, and are more influenced by, the differences among the adults than are younger children. A tendency was also found for the ordering of experimenters (according to the average response of each *E*'s *Ss*) to be similar at preschool and late elementary school age for boys, while the ordering for girls indicated that adults who produced high increments in response following the introduction of social reinforcement with young children tended to produce low increments in response with older children. In other words, men who were effective with young children tended also to be effective with older children, whereas women who were effective with young children tended to be less effective with older children than did women who had been less effective with the younger children.

C. Chronological Age of *S*

The significance of the child's chronological age in determining the effectiveness of social reinforcement has been investigated in several studies. The cross-sex effect discussed above is found with older preschool and elementary school children, but if younger children (3 and 4 years) are used, somewhat different results are obtained (Stevenson, 1961). Very small changes in performance occur if the reinforcing agent is a man, but both boys and girls show significant increases in rate of response if the agent is a woman. Such results are expected if it is assumed that, through her role as principal caretaker of young children, the mother becomes the primary love-object of the young children and that her presence and her comments acquire the capacity for reinforcing behaviors not associated with primary drives. If the relationship generalizes to other women, it would be predicted that women would be more effective in modifying the performance of young preschool boys and girls than would men.

A greater understanding of the developmental changes in the reinforcing and motivational properties of social reinforcement is obtained if performance is compared across a number of experimental conditions. Stevenson and Cruse (1961) had different groups of five- and twelve-year-old children perform a two-hole sorting task under four different conditions: (a) *E* made supportive comments about *S*'s performance; (b) *E* was present, attended to *S*'s performance, but made no comments; (c) *E* was in the room, but at a distance from *S* and ostensibly at work; and (d) *E* made critical comments about *S*'s performance. The dependent variable was the number of responses made until *S* initiated the termination of the task. Social reinforcement was more effective with five-

year-olds than with twelve-year-olds, but for both groups social reinforcement resulted in a greater number of responses than did passive attention. Rather than finding a further decline in performance when the adult did not attend to the child, an increase in the number of responses occurred. It appears that the structure of the task was changed when the adult was not attentive or responsive to the child's behavior. Younger children elaborated the task into a game and older children appeared to have increased curiosity concerning what the whole thing was about. When the adult was critical of the child's performance, younger children, as might be expected, quickly gave up. The older children, however, made the greatest number of responses in this condition.

The level of difficulty of the task appears to influence the effectiveness of social reinforcement. The older children in the above study appeared to be uninterested in this simple task; it was not impressive or informative for them to be told by an adult that they were doing well. When the adult stated that they were not doing well, however, they seemed to be perplexed and began to work vigorously. Quite different results may arise when more complex tasks are used, but the possibility exists that as age increases, criticism may have a greater facilitating effect on performance by increasing motivation than do supportive comments in reinforcing responses.

D. Mental Age of *S*

Up to a certain intellectual level, the mental age of the child appears to be positively related to the rate of response in the marble-dropping task. In a study of institutionalized and noninstitutionalized normal and retarded children with an average chronological age of approximately 9 years, Stevenson and Fahel (1961) report significant positive correlations for the retarded children between rate of response during the first, base-rate minute and mental age (with chronological age held constant). The correlations for the normal children were not significant; however, when the correlation was computed for a group of noninstitutionalized normal children of the same average mental age, but lower chronological age (4.2 years), as the retarded children, the correlation was again significantly positive. The significant correlation between mental age of retarded children and initial rate of response has also been found by Stevenson and Snyder (1960) and Zigler (1963). A significant correlation between the base-rate of response and mental age is thus found with younger normal *S*s, as well as with retarded *S*s, but not with the older normal *S*s. In other words, below a certain intellectual level, reactivity to the adult's instructions is significantly related to mental age, but above that age it is not. This may mean that up to a certain age the brighter the child, the more effective are adult instructions in motivating him to perform.

Mental age has not been found to be significantly related to the change in rate of response that occurs following the introduction of social reinforcement. In none of the studies discussed in the preceding paragraph was a significant relationship found.

A negative relationship has been found between mental age and the amount of time the child will participate in the task before requesting to leave. In various studies with retarded children, significant *r*'s of —.37 (Zigler, 1961), —.18 (Zigler, 1963), and a nonsignificant *r* of —.24 (Zigler & Williams, 1963) have been reported. It is impossible to know whether the brighter children were less affected by social reinforcement or whether brighter children tend to be better able to express their interest in leaving the task.

E. Intellectual Status of *S*

Two recent studies have reported remarkably similar findings when comparisons were made of the performance of normal and retarded institutionalized children in reinforcement and nonreinforcement conditions (Stevenson & Fahel, 1961; Zigler, 1963).[1] In neither study was there an over-all significant difference between the performance of the normal and retarded groups. In both studies, the type of subject exerted a significant effect on performance only in interaction with the variable of institutionalization. The levels of response attained in conditions involving either the presence or absence of social reinforcement were similar within each study for the institutionalized normal and retarded children. The significant interaction appears to arise from the fact that the nonstitutionalized retarded child, in contrast to the comparable normal child, performed at a higher level under the nonreinforcement condition. With this exception, then, it may be concluded that the child's intellectual status is not a significant variable in studies of social reinforcement.

F. Social Class

An explicit attempt to determine possible differences in the effect of social reinforcement as a function of the child's membership in the middle or lower socioeconomic class has been reported by Zigler and Kanzer (1962). Reasoning that being correct may be more reinforcing for middle-class children than it is for lower-class children and that being praised may be more rein-

[1] In all subsequent citations, except when noted, the dependent variable in the studies by Stevenson and his associates is the increment in response over a base-rate period with a six-hole marble-dropping task, and in the studies by Zigler and his associates, it is the time spent in the two-hole marble-sorting task prior to *S*'s initiating the termination of the task.

forcing for lower- than for middle-class children, these investigators employed two types of verbal statements. Half a sample of seven-year-old children from each socioeconomic class were reinforced with the words, "good" and "fine," and half with the words, "correct" and "right." There was a significant interaction between socioeconomic class and type of social reinforcement. Praise was less effective with the middle-class children than were the statements implying correctness of response, while the opposite relationship appeared with the lower-class children. This is an exciting finding, and it is important that this study be replicated and extended with other groups of children, especially since such a high degree of overlap in the ranges of performance for each of the four groups was found. A significant question for this, and for other studies of social reinforcement, is why the performance of some children is only minimally affected, regardless of the class of social reinforcers used, and the performance of others shows a dramatic effect.

G. Order of Birth

The relationship of order of birth and children's reactivity to social reinforcement has been investigated in several studies, but none offers convincing evidence that a relationship exists. Walters and Ray (1960) included both first- and later-born children in their study of the effects of anxiety, social isolation, and reinforcer effectiveness. First-born children were slightly, but not significantly, more responsive to social reinforcement than were later-born children when they were not subject to social isolation, but this pattern did not occur under conditions of social isolation. The dependent variable was the increase in number of correct responses in the two-hole marble-sorting task. A marginal relationship between birth order and increase in rate of response following social reinforcement has been reported by Patterson *et al.* (1963).

Gilmore and Zigler (1963) have assumed that first-borns have a greater likelihood than later-borns of receiving a continuing supply of social support. First-borns would consequently be more satiated, and should therefore be less responsive to social reinforcement than later-borns. At the same time, it is assumed that the absence of social reinforcement should be more frustrating to the first-borns, who are more accustomed to having their performance consummate in approval. Later-borns remained at the sorting task significantly longer than the first-borns with social reinforcement, but there was only a slight tendency for first-borns to remain longer than the later-borns when social reinforcement was not provided. The interaction between experimental condition and order of birth was significant. Unfortunately, the experimental sessions were preceded by pretraining games played under differing conditions of social support, and the sample of children contained approximately twice

as many first-born girls as boys and second-born boys as girls. These factors may contribute to effects which, although not demonstrable statistically with a small sample, influence the results obtained.

H. Parents as Reinforcing Agents

Most studies of social reinforcement have utilized strange adults as the reinforcing agents. The question arises, then, as to what would happen if the children's parents provided the social reinforcement. The parents of 41 children ranging in age from 5 to 9 years served as experimenters in a study by Patterson *et al.* (1963). An analysis of covariance (partialling out the child's initial preference) of the relative rate of "correct" responses during the reinforcement period indicates a significant cross-sex effect. Mothers were more effective with their sons than with their daughters, and fathers were more effective with their daughters than with their sons. The writers state that their impression is that the parents were less effective during the operant, or base rate, period than were strangers.

Data from a study by Stevenson, Keen, and Knights (1963) provide a direct test of the relative effectiveness of parents and strangers as reinforcing agents for preschool children. It was assumed that preschool children may be partially satiated for parental support because of the continuing supportive role played by most parents. It was predicted, therefore, that social reinforcement by parents, compared with that by strangers, would produce smaller increments in the children's rate of response in the marble-dropping task. In line with this prediction, the results indicate a significantly higher level of performance for children tested by strangers than for children tested by their parents. Fathers, and male adults in general, were less effective as reinforcing agents than were mothers or other females. Of the children tested by their parents, only girls tested by their mothers showed an increase in rate of response after the introduction of social reinforcement. This was in contrast to the results for children tested by strangers, where the only group showing a decrease in rate of response was boys tested by male adults.

I. Peers as Reinforcing Agents

The effect of using peers as reinforcing agents has been reported by Patterson and Anderson (1963). Peers of children from 7 to 10 years were effective as reinforcing agents, as reflected in significant increases in rate of response and in incidence of "correct" response. In an analysis of variance of the changes in incidence of "correct" response, a significant difference according to the child's grade in school and a significant interaction between grade and friend-

ship status of the peer were found. The second-grade children showed only moderate changes in behavior, while the third- and fourth-grade children showed marked changes. The children in the second and third grades tended to show a greater change in behavior when they were reinforced by friends, but the fourth-grade children tended to show a greater change when they were reinforced by children who were not their friends.

Hartup (1963) has investigated the effectiveness of four- and five-year old children as reinforcing agents for performance by their peers. A picture sociometric test was used to determine the peers which each child liked and the peers the child disliked. Half the *S*s were subsequently reinforced in a marble-dropping task by "liked" peers and half by "disliked" peers. Rate of marble dropping was at a higher level during the testing period when the reinforcing agent was a "disliked" rather than a "liked" peer. The rate decreased below that of the base-line minute in all groups except the group of five-year-old *S*s tested by a "disliked" peer, where there were increments in rate of response.

Hartup suggests several possible interpretations of the results. The presence of "liked" peers may interfere with marble dropping because of the greater tendency for them to elicit friendly approach responses or bids for attention from their subjects. The presence of "disliked" peers may have several effects. It may increase the child's anxiety, resulting in an increase in the child's level of motivation and a higher level of performance. It may increase attention to the task as the child attempts to avoid interacting with the threatening person. Finally, nonaggressive approval and attention from a disliked peer may have a greater incentive value than approval and attention from a friend. Further research with peers as reinforcing agents is obviously needed before the validity of the alternative interpretations or the basis of the discrepancies between the results of the Hartup and Patterson and Anderson studies can be clarified.

III. Antecedent Variables

A. Child-Rearing Practices

It has been pointed out that within most groups of children there are large differences in the degree to which social reinforcement is effective in modifying behavior. This variability may be derived in part from the experiences that children have had with their parents. The consequences of such experiences may generalize to the experimental situation and to other adults, and thereby influence the child's responsiveness to social reinforcement.

Patterson *et al.* (1963) interviewed mothers concerning their child-rearing practices, and then correlated the ratings of the data from the interviews with the degree to which children showed changes in "correct" response in the

marble-sorting task following the introduction of social reinforcement. One of the child's parents acted as the reinforcing agent. Because of the necessity of breaking down the sample according to sex of parent and sex of child the number of subjects in each subgroup was relatively small (approximately 10). Perhaps the most provocative finding is the lack of a relationship between the frequency with which the parent reported providing positive reinforcement at home and his effectiveness as a reinforcing agent in the laboratory. Of twelve relevant correlations, only one was even in the expected direction. For a seven-to-nine-year-old group of 59 children whose mothers were the informants in an interview about child-rearing practices, Cairns (1963a) found a significant negative relationship between fathers' reported use of praise in the home and boys' responsiveness to social reinforcement provided by an adult male *E*. No significant correlation was found for either boys or girls with mothers' reported use of praise in the home, or for the girls with fathers' reported use of praise. Cairns used a three-plunger pin ball machine and reinforced choices of the plunger which had been least frequently selected during ten prereinforcement trials.

When the father was the reinforcing agent in the study by Patterson *et al.* (1963), boys who showed marked increases in incidence of "correct" response were from homes described as warm and laissez-faire, whereas girls who showed marked changes were from restrictive homes. When the mother was the reinforcing agent, boys who showed marked changes in behavior were from homes described as cool and restrictive, whereas girls who showed marked changes were from homes described as laissez-faire. In the Cairns study (1963b) no significant relationships were found between children's responsiveness to social reinforcement and parental warmth, dependency, or type of discipline. The importance of the discrepancies between the two studies can only be determined through additional research, but the data do seem to indicate that children whose parents use high frequencies of praise and approval at home are less responsive to social reinforcement given in an experimental task. These results are in line with those of studies comparing parents and strangers as reinforcing agents. If the variable of satiation operates to reduce the effectiveness of parents as compared with strangers, it would also be expected to result in the lower effectiveness of the more nurturant, supportive parents.

B. Social Deprivation

If social forms of reinforcement operate in a fashion similar to other forms of reinforcement, it would be predicted that the degree of social deprivation the child has experienced at home would be a significant variable in determining his response to social reinforcement. Children who have had a high degree

of social deprivation should be highly responsive to social reinforcement. Zigler (1961) investigated such a possibility with a group of institutionalized retarded children. Two psychologists rated the material in the case histories of 60 children according to the degree of social deprivation the children had experienced, and on the basis of these ratings the children were placed into "high deprivation" and "low deprivation" groups. The more socially deprived children were found to spend a significantly longer time at the marble-sorting task than were the less socially deprived children. Twice as many children in the former group made the maximum number of responses possible (400) in the task as did children in the latter group.

Zigler and Williams (1963) returned to the institution 3 years later to determine the effect of continued institutionalization on the performance of these children. A comparison of the results of retesting with those obtained during the original testing indicates that children with less social deprivation prior to institutionalization show a much greater increase in response over the 3-year period than do children who had suffered more social deprivation. Residence in an institution had relatively little effect on the more socially deprived children. In the analysis of the retesting data, all the significant effects were associated with reinforcement conditions, with no differences in performance related to preinstitutional social deprivation.

The effects of social deprivation have not been investigated with normal children, but the Zigler data point to this as a possibly significant determinant of their responsiveness to social reinforcement. The effects found by Zigler are even more impressive when one realizes that hardly any of the retarded children came from supportive environments, and practically all came from what would be classed as deprived backgrounds. If children from the full range of backgrounds were included, an even more marked relationship between degree of deprivation and reactivity to social reinforcement may be found.

C. Personality Characteristics of *S*

Some interesting relationships between teachers' ratings of 50 personality characteristics of children (Becker, 1960) and the children's behavior in response to social reinforcement have been reported by Patterson and his associates (Patterson *et al.*, 1963; Patterson & Anderson, 1963). In the first study, where parents were the reinforcing agents, boys who showed marked increases in rate of response were rated by their teachers as being happy, responsive, optimistic, and intelligent. Girls who showed marked increases were rated as being loving, interesting, optimistic, trusting, relaxed, placid, objective, nonchalant, stable, easy going, outgoing, sensitive, and as showing "meaningless" behavior in the classroom.

In the second study, where peers were the reinforcing agents, the number of significant correlations between change in rate of response and teachers' ratings did not exceed those which would occur by chance. Some evidence was found for a relationship with teachers' ratings for boys and incidence of correct response, but the relationship did not hold for girls. Boys who showed the most marked changes in response were described by their teachers as being responsive, excitable, conceited, self-centered, adventurous, intelligent, and self-confident.

It is not at all obvious just what these correlations mean, except that children who were responsive to social reinforcement provided by their parents were the types of children that teachers liked to have around, while the boys who were more responsive to their peers appeared to be somewhat less pleasant, but still bright and responsive.

In Cairns' (1963b) investigation of the antecedents of social reinforcer effectiveness, teachers ranked the children on scales of help-seeking and conformity, and rated the children on scales of help-seeking, negative attention-getting, aggression, and suggestibility. Only the ranking on dependency was significantly related to the effectiveness of social reinforcement, and this relationship was found only for girls. It is quite reasonable, as Cairns (1963b) points out, that the more dependent children are oriented toward the behavior of the adult rather than to other cues in the experimental setting, and consequently would be more influenced by the adult's response than would less dependent children.

In a very interesting study, Cairns (1961) investigated the influence of dependency-inhibition on the effectiveness of social reinforcement. A group of 73 adolescent boys in a detention home were rated by their counselors according to the degree to which, in their everyday behavior, they avoided or resisted placing themselves in a dependent role. It was assumed that children who inhibit their dependency behavior would be less responsive to adult praise and approval than children who do not inhibit dependency behavior. An attempt was made to condition confiding responses of adolescent boys through social reinforcement. "Confiding" responses consisted of any reference to the subject's home or family. A significant conditioning effect was found for boys rated as showing low inhibition of dependency, while the boys rated as showing high inhibition of dependency actually decreased significantly in their number of confiding responses.

The results showing that dependent children tend to be more susceptible to the effects of social reinforcement than nondependent children led Cairns (1963a,b) to attempt to produce a group of dependent children through experimental procedures. Children were shown a cupboard of toys and in order to obtain a toy the child had to indicate his choice to the experimenter. The experimenter reinforced each help-seeking response, and reinforcement was contingent upon the child's attempting to gain the experimenter's attention. The

performance of these children was compared on the marble-sorting task with that of children who were allowed to get the toys themselves and for whom reinforcement was not contingent on responses. A significantly greater increase in frequency of "correct" responses following the introduction of social reinforcement was found for the group that had received "dependency" training. This is a clever study and appears further to establish one domain of behavior, dependency, as being a significant determinant of the child's responsiveness to social reinforcement. If, because of tendencies developed from prior experiences, or because of tendencies developed in the experimental situation, the child looks to the adult for support and guidance, he will more likely be affected by such support and guidance when they are given in the experimental task.

IV. Environmental Variables

Institutionalization

A great deal of attention has recently been paid to the effects of institutionalization on children's responsiveness to social reinforcement. It is readily apparent to any visitor that children in an institution are extraordinarily interested in receiving attention and response from adults. In line with this observation, the primary assumption behind most of the studies is that institutionalized children tend to be relatively deprived of adult contact and approval and hence have a higher motivation to secure such contact and approval than do noninstitutionalized children.

The initial impetus for these studies was the widespread assertion that retarded children show rigid and perseverative behavior because of an inherent rigidity in their personality structure (Kounin, 1941). An equally plausible hypothesis is that retarded individuals appear to be rigid because any act which eventuates in adult approval is more strongly reinforced for them than for normal individuals, not because they are retarded, but because they are institutionalized. The historical background and recent research related to the topic of rigidity in the retarded has been reviewed by Zigler (1962).

Zigler, Hodgden, and Stevenson (1958) had normal and retarded children of comparable mental ages sort pegs into two holes of a container. Half the children received social reinforcement, and for the other half the experimenter maintained an attentive, but nonsupportive role. The retarded children were more strongly affected by both attention from an adult and adult approval than were the normal children, as evidenced by the amount of time spent in the task prior to the children's initiating its termination. The difference in performance between the two conditions was much greater for the retarded children. It was concluded that what may appear to be rigid behavior on the

part of institutionalized retarded individuals may simply be a reflection of their higher motivation to secure social interaction and approval through compliance and persistence. [Familial retarded children have been used in all the studies to be discussed, but a study by Shepps and Zigler (1962) reports no difference in the effects of social reinforcement on the behavior of familial and organic retardates.]

In the Zigler *et al.* (1958) study, institutionalization and retardation were confounded variables, and it was necessary to ascertain whether the results could, indeed, be attributed to institutionalization. Three studies have given convincing support to the general argument that the results were due to the fact that the retarded children were institutionalized. Stevenson and Fahel (1961) tested 112 normal and 112 retarded children in the marble-dropping task. One-half of each group resided in an institution and the other half resided at home. The only significant main effect was associated with institutional status; reinforcement condition, complexity of the task, and intellectual status, the other variables studied, exerted significant effects only in interaction with each other.

Green and Zigler (1962) report a similar study employing normal children and institutionalized and noninstitutionalized retarded children. The performance of the two groups of noninstitutionalized children was similar, but differed from that of the institutionalized retarded. A more elaborate study by Zigler (1963) reports the results of testing 128 normal and retarded children. Zigler used a different version of the task and a different response measure from those used by Stevenson and Fahel (the former used time spent in a two-hole task and the latter used increase in rate of response in a one- or six-hole task), but again a significant main effect associated with institutional status was found. In addition, there was a significant difference in the performance of children who received social reinforcement and those who did not. There was no significant difference between the over-all performance of the normal and retarded children.

In the Stevenson and Fahel study, the institutionalized children tested on a form of the task involving six alternative holes into which the marbles could be inserted tended to show greater increments of response when the experimenter did not give social reinforcement than when she did. When only one hole was available, and when noninstitutionalized children were used, the reinforcement condition resulted in the higher increments in response. Zigler found that in three of his four comparisons social reinforcement resulted in the children's remaining longer at the task. The hypothesis employed to explain the difference in the effect of social reinforcement between the two studies is that in the complex form of the task the institutionalized children were made more anxious, and that social reinforcement under such conditions may reduce motivation, thus resulting in lower levels of performance. The hypothesis will be discussed in detail in a later section.

In a study testing the limits to which social reinforcement would maintain response for institutionalized children, Stevenson and Cruse (1961) allowed retarded children to sort marbles for 5 successive days, with a maximum time for each session of 30 minutes. More than half the subjects remained at the task for the maximum amount of time on all 5 days. Even when the experimenter was attentive, but provided no reinforcement, no fewer than half the children on any day remained at the task for the maximum amount of time. This behavior is in striking contrast to that of the noninstitutionalized normal children, none of whom by the fourth day remained at the task for 30 minutes under either condition.

The effects of brief and extended institutionalization have been reported by Stevenson and Knights (1962a). An institution was visited in which the children remained at home during the summer. In the fall, immediately after the children had returned to the institution or 12 weeks after they had returned, the children were tested with the six-hole marble-dropping task. In general, no changes in performance as a function of length of institutionalization were found for boys, but significant differences were found for girls. In contrast to what had been anticipated, girls were significantly more responsive to social reinforcement immediately after they returned to the institution than they were after 12 weeks. (The total number of responses made during a 7-minute period was used as the dependent variable.) The most reasonable interpretation of these findings appears to be that separation from home and family results in more intense feelings of deprivation and isolation than occur after the child has readjusted to the institutional setting. Institutionalized children may thus have a greater motivation for adult contact and support than noninstitutionalized children, but the level of such motivation may be highest immediately after institutionalization.

In none of the above studies has a significant relationship been found between length of institutionalization and responsiveness to social reinforcement. This is somewhat perplexing, especially since institutional residence clearly results in increased responsiveness to social reinforcement. It may be that the use of children results in too restricted a range in length of institutionalization (the mean length is usually around 2 years), or that other variables, such as preinstitutional social deprivation or age at institutionalization, obscure the relationship. The problem clearly needs further analysis.

V. Experimental Variables

Availability of Social Stimuli

The study which has stimulated the greatest amount of research in the area of social reinforcement is that of Gewirtz and Baer (1958a) on the effect of brief

isolation on children's subsequent responsiveness to social reinforcement. The question that Gewirtz and Baer sought to answer was whether the value of social stimuli as reinforcers is increased following isolation. Their results, and the results of other studies (Stevenson & Odom, 1961; Erickson, 1962; Hill & Stevenson, 1964), give an affirmative answer to this question. Gewirtz and Baer attributed the increased effectiveness to the social deprivation which the children experienced during isolation. Other writers have offered alternative interpretations, and a series of experimental studies has attempted to evaluate the validity of the various alternatives.

1. *The Social Deprivation Hypothesis*

In the study by Gewirtz and Baer, preschool children were tested with the two-response form of the marble-sorting task. Adult approval of the initially nonpreferred response resulted in a general increase in the relative frequency of this response over a baseline level, and the mean effectiveness of adult approval was significantly greater when a 20-minute period of isolation preceded the experimental session. Reinforcement was more effective after isolation only with children of the opposite sex from the adult. The effectiveness of adult approval was positively correlated with the child's age, and with his tendency to seek adult approval in other settings (as evaluated by teachers' ratings).

If a prior period involving the unavailability of social stimuli results in increased effectiveness of such stimuli, the converse should also be true according to a deprivation-satiation model: a prior period in which there is an abundance of approval and contact should result in a reduced effectiveness of social stimuli as reinforcers. Their first experiment was replicated and extended (Gewirtz & Baer, 1958b) with three experimental conditions: a prior period of isolation, a prior period of drawing and cutting in which the experimenter responded to the children in an approving and supporting fashion, and immediate testing of the children as they came from the classroom. Social reinforcement was most effective following deprivation, and least effective following satiation. The children spontaneously made more initiations of social contact and exhibited more intense social interaction following deprivation than following nondeprivation. Gewirtz and Baer offer a conservative interpretation of their data, and although they accept the conclusion that social reinforcers follow the deprivation-satiation model, they also point to the conditions that would be necessary for a decisive validation of this conclusion, such as separation of the components of social reinforcement and the use of other reinforcing stimuli following isolation.

2. *The Arousal Hypothesis*

Walters and Ray (1960) were among the first to challenge the conclusion that the isolation studies point to the operation of a social drive. Walters and his

colleagues have proposed, instead, that isolation may be emotionally arousing, and that the increased susceptibility to social reinforcement following isolation is a consequence of this arousal rather than of social deprivation (Walters & Karal, 1960). It is assumed that emotional arousal may function (a) to increase the intensity of responding and (b) to alter the range and nature of cues to which the child responds, so that an emotionally aroused individual learns more rapidly to identify the occasions on which reinforcement will occur. To determine whether emotional arousal or social isolation is the major determinant of the enhanced effectiveness of social reinforcement, children were either isolated for 20 minutes or were tested immediately after 20 or more minutes of free interaction with their peers. Half the children were subjected to a potentially anxiety-invoking experience by being taken to the experimental rooms by a strange, noncommunicative man. The remaining children were taken to the experimental rooms by the familiar and friendly school secretary. Children subjected to the experience with the stranger were highly responsive to social reinforcement in the marble-sorting task, regardless of whether they had been isolated. A smaller over-all difference was found for the effect of isolation.

Other studies by Walters and his colleagues provide additional evidence in support of this hypothesis (Walters & Karal, 1960; Walters, Marshall, & Shooter, 1960; Walters & Henning, 1962; Walters & Foote, 1962). Walters and Henning (1962) suggest, therefore, that social isolation increases the effectiveness of social reinforcement only when isolation serves as an emotionally arousing stimulus. Further, it is suggested (Walters, Callagan, & Newman, 1963) that the results of the studies indicating greater activity to social reinforcement by institutionalized children may be due to the fact that they are less accustomed than noninstitutionalized children to social interaction with unfamiliar adults. The stranger may act as an emotionally arousing stimulus and result in the children's being more susceptible to adult influence.

3. *The Frustration Hypothesis*

The act of isolating a child may produce still other consequences than an increase in anxiety, as Hartup and Himeno (1959) have pointed out. These writers note that in previous studies (Hartup, 1958; Rosenblith, 1959) inconsistent nurturance on the part of an adult appears to frustrate the child's dependency behavior. Reassurance in the form of praise or support would have the effect of reducing this frustration. They predict, therefore, that disruption of an interaction between an adult and a child, whether by inconsistent nurturance or by social isolation, should increase a child's dependence and thereby increase the effectiveness of social reinforcement in modifying his behavior. Their approach to testing this line of reasoning was to determine whether isolation, which presumably results in frustration, would not evoke a

higher incidence of aggressive behavior, a common response to frustration, than would a prior period of supportive interaction with an adult. After a 10-minute period of isolation children did show a greater frequency of aggressive behavior in doll play than after 10 minutes of interaction with the adult. The implication of these results is that isolation produces frustration effects which may, in other studies, play a significant role in modifying children's responses to social reinforcement.

Cairns (1963b) has investigated the effects of frustration on children's response to social reinforcement. Children's attention was directed to a cupboard containing a number of highly attractive toys. Half the children were told that they could select a toy to play with each time the experimenter rang a bell (six times in 15 minutes), and that each time they selected a toy they would also be given a "surprise" (trinkets, balloons, etc.) that they could keep. The procedure for the other half of the children was designed to induce frustration. They were shown the cupboard and were told that other children had been able to play with the toys and had received "surprises," but for now the experimenter was busy and had some work to do. The experimenter busied himself for the next 25 minutes, pausing each 5 minutes to comment to the child, and gradually making it clear that the child would neither get to play with the toys nor get any "surprises." When the children were then tested with the two-response form of the marble-sorting task, the children who had been frustrated showed significantly smaller increases in frequency of "correct" responses following the introduction of social reinforcement than the children who had not been frustrated. Frustration thus appeared to decrease the effectiveness of social reinforcement. In another aspect of the study by Cairns (1963b), using a similar procedure with a shorter period of frustration, similar results were found but the differences were not statistically reliable. Cairns interprets these findings as being a result of interfering responses derived from the frustration.

4. *The Stimulus-Deprivation Hypothesis*

It is obvious that isolation involves a reduction in the presence of a wide variety of stimuli, and children who are isolated may be subject to general stimulus deprivation rather than merely to deprivation of social stimuli. As a consequence, the effectiveness of social stimuli as reinforcers may be reduced when other types of stimuli are available during the isolation period. Stevenson and Odom (1961) tested this hypothesis by utilizing two conditions of isolation: the typical condition where children are simply placed in a vacant room and a condition in which the room contained a wide variety of interesting toys that the child was invited to play with. The presence of other stimuli during the isolation period did not result in a significant decrease in the effectiveness of social reinforcement over that which was found when no toys were present. The

performance in the marble-dropping task of both isolation groups was consistently above that of a control group which did not experience isolation. It appeared, therefore, that social deprivation, rather than general stimulus-deprivation, was the basis of the enhanced effectiveness of social reinforcement following isolation.

An alternative approach to testing the hypothesis is to provide other than social forms of reinforcement following isolation. Erickson (1962) attempted to condition children to select one class of nouns from successive pairs of nouns by reinforcing these choices with verbal or nonsocial (marble) reinforcement. Prior to the experimental task, half the children were given a 15-minute period of social deprivation (having no social stimuli available while solving puzzles) and half, social satiation (receiving social reinforcement from the adult while solving puzzles). The interaction between type of pretask condition and type of reinforcement was significant; children who had received social deprivation showed greater evidence of conditioning with verbal reinforcement than did children who had received social satiation, but there were no consistent differences between the deprived and satiated children when they received nonsocial reinforcement.

It might be concluded from these two studies that isolation does have its major effects on the later reinforcing value of social stimuli. On the basis of further investigation, however, it appears that this is an oversimplified conclusion. Hill and Stevenson (1964) employed three conditions of isolation in a recent study: the children remained alone in an empty room, the children remained alone but viewed an interesting abstract film, or the experimenter was the children's companion in viewing the film. The absence of only social stimuli had a less significant effect on subsequent performance in the marble-dropping task than the absence of both social and interesting visual stimuli. For boys, the results of the condition involving only social deprivation were more similar to those of the nondeprivation condition than to those involving both social and sensory deprivation. The results for the girls were less systematic. Thus, depending upon whether the child is actively playing with toys or is passively viewing a film, isolation has different effects, and the degree of such differences is related to the sex of the child. The stimulus-deprivation hypothesis is, for the moment, left in limbo.

5. *The Information Hypothesis*

The fifth hypothesis to account for the results of the deprivation-satiation studies has been presented by Cairns (1963a), who objects to the discussion of these studies in terms of motivational variables on the grounds that the elaboration of motives to account for the reinforcing value of various stimulus events is an unparsimonious approach, that there has been no demonstration of

the acquisition of a strong secondary appetitive drive, and that the empirical data do not clearly support a motivational interpretation. Cairns proposes that satiation has the effect of increasing the ambiguity of the stimulus, and that the decrement in the effectiveness of social reinforcement is a result of the change in the "stimulus" function of approval derived from its redundant recurrence during the satiation period. Cairns further proposes that the increased effectiveness of social reinforcement following deprivation may be due to approval having a different meaning and increased informational value following isolation from that found in a casual, play-type setting. This is an interesting hypothesis, but more specific statements are required concerning how satiation comes to increase the ambiguity and deprivation to increase the informational value of social reinforcers. The hypothesis is a difficult one to evaluate in research with children.

6. *The Anxiety Hypothesis*

The base rates of preschool children tested by their fathers or strange men have been found to be significantly higher than those of preschool children tested by their mothers or strange women (Stevenson *et al.*, 1963). These writers have assumed that children were made more anxious by their fathers (and men in general) and that the higher motivation derived from this anxiety was evidenced in a higher initial rate of response. Since it is uncommon for men or for fathers to visit nursery school and to play games with children, the children may have been more excited at the prospects of playing games with men than with women. The lower effectiveness of men than women as reinforcing agents was assumed to be due to the fact that the supporting statements had the effect of reducing the children's anxiety, with a resultant decrease in their rate of response. It is hypothesized, therefore, that social reinforcement thus may have two different functions, depending on the child's level of anxiety: it may reduce anxiety in a tense situation thus reducing the rate of response or it may reinforce performance when there is less evidence of tension.

Stevenson and Hill (1963) have tested these predictions with elementary school children. The children were presented with one of two pairs of form-board-like puzzles. One pair of puzzles was easy to assemble, but the other two puzzles, although seemingly appropriate for the child and obviously solvable, actually were extremely difficult and could be solved by an adult only with extreme persistence. It was assumed that the success the children experienced with the easy puzzles would establish the experimental setting as a benign and comfortable situation, and would tend to reduce any anxiety that the children may have had upon entering the experiment. On the other hand, it was assumed that attempting, but failing, to solve the difficult puzzles would increase their anxiety. The children were then tested in the marble-dropping task; half the

children received social reinforcement and half did not. For the groups experiencing success, the reinforced group should show, according to the reasoning discussed above, greater increases in rate of response than the nonreinforced group. For the subjects experiencing failure, the reinforced group, presumably experiencing reduced anxiety through social reinforcement, should be below the nonreinforced group, whose anxiety is presumably unabated or increased by the nonsupportive adult. The results gave clear support to these predictions; a significant interaction between pretraining condition and reinforcement condition was obtained.

A study by Shallenberger and Zigler (1961) adds further information relevant to the discussion of the effects of prior success and failure on children's responsiveness to social reinforcement. They employed a two-part form of a marble-sorting task in which the two parts differed only in that the holes into which marbles of two colors were to be inserted were reversed for Part II. Prior to the sorting task the children played three games in which half met with consistent success and were highly praised by the adult and half met with consistent failure and were criticized. It may be assumed that for the latter children the pretraining games were an anxiety-arousing experience. Institutionalized retarded and noninstitutionalized normal children were selected as subjects. The institutionalized children who had been criticized remained in Part I of the task for a shorter period of time before requesting to leave than did the children who had been praised, although not to a reliable degree. The differences were in the opposite direction on Part I for the noninstitutionalized children. Both groups who had been criticized remained in the task longer in Part II than in Part I, while the children who had been praised remained in the task longer in Part I than in Part II. The results for the "failure" group may be explained if it is assumed that failure resulted in increased anxiety and that social reinforcement on Part I reduced this anxiety, this anxiety, thereby making social reinforcement on Part II more effective. The results for the "success" groups may be explained if it is assumed that the pretraining games reduced anxiety, thereby making social reinforcement more effective on Part I, and that satiation effects derived from the pretraining games and from Part I reduced the effectiveness of social reinforcement during Part II.

This interpretation is somewhat similar to that presented by Shallenberger and Zigler, although they posit the operation of positive reaction tendencies (the motivation to interact with an adult) and negative reaction tendencies (the wariness of adults) during children's contacts with strange adults. Both tendencies are assumed to be greater in institutionalized children than in noninstitutionalized children. The negative reaction tendencies of institutionalized children are assumed to decrease to a greater degree with praise and support than are those of noninstitutionalized children. The positive reaction tendencies, in

contrast, are assumed to decrease through satiation and fatigue to a greater degree in the noninstitutionalized children. The predictions made from this position are also generally supported by the results of the study.

For highly anxious children, it may be assumed that conditions that increase (or fail to reduce) anxiety will result in higher levels of performance than conditions which reduce anxiety. That institutionalized children have higher levels of test anxiety than noninstitutionalized children has recently been established by Knights (1963). Being tested by an attentive, but noncommunicative adult, then, may be a condition which increases or at least does not reduce institutionalized children's anxiety, and being tested by an informative and supportive adult may reduce their anxiety. It will be recalled that when institutionalized children were tested with the six-hole form of the marble-sorting task the increase in rate of response over a base rate period was greater in a nonreinforcement than in a reinforcement condition (Stevenson & Fahel, 1961). This may be due to the fact that the children's anxiety was high in the nonreinforcement condition, and was reduced for children in the reinforcement condition when they were given information about the adequacy of their response. The rate of response would then be predicted to be higher in the former condition.

If this argument is valid, two successive experiences with nonreinforcement should result in even higher levels of response than occur in an initial nonreinforced period. Stevenson and Snyder (1960) tested institutionalized retarded children in the marble-sorting task on two successive 7-minute sessions. Rate of response was higher for the initial testing for children in the nonreinforcement than in the reinforcement condition. The highest level of response attained by the different groups of children tested on the second session was in the group that had had two successive periods of nonreinforcement. In line with the Shallenberger and Zigler results, rate of response increased from the first to the second sessions when the children were given social reinforcement in each session, and the increase over the first session was greater for children who had received two successive sessions of reinforcement than for children who were given reinforcement after nonreinforcement.

Another recent study (Ruebush & Stevenson, 1963) indicates that the level of performance in a condition involving social reinforcement is lower for children with high anxiety than for children with lower levels of anxiety. Children were selected on the basis of their responses to an anxiety questionnaire to form "high" and "low" anxious groups. The levels of performance following social reinforcement in the marble-sorting task were negatively related to the children's level of anxiety.

The hypothesis used in accounting for this group of studies does not go far in providing a satisfactory account of the results of the studies by Walters and

his associates. It can only be assumed that the operations involved in the different studies involve the activation of different processes, and, for the moment, the critical differences among them are not clear.

VI. Comparison with Other Forms of Reinforcement

A. Form of Reinforcement

Several investigators have compared the effectiveness of social reinforcement with other forms of reinforcement. Terrell and Kennedy (1957), using preschool and elementary school children, found that the trials to criterion in a two-choice discrimination learning task were ordered, depending on the form of reinforcement, in the following fashion: candy, praise, token, reproof, and signal light. The children learned the discrimination nearly twice as quickly when the tangible reward of candy was provided for correct response as they did when they were praised for correct response.

The greater effectiveness of praise over a signal has also been found by Horowitz (1963b), who compared the learning rates of elementary school children in a three-choice discrimination problem with social reinforcement and with a buzzer as reinforcement. The latter group showed a significantly slower learning rate than the former group. The greater effectiveness of candy over social reinforcement has also been found by Horowitz (1963a). Vocal responses (naming the correct stimulus among three) in a group of retardates were reinforced with candy, praise, or smiling. When partial reinforcement was provided, no differences among the conditions appeared, for none of the children reached the criterion for acquisition in 80 trials. When continuous reinforcement was provided, the mean number of trials to criterion was lowest with candy and highest with verbal reinforcement. When candy was coupled with verbal reinforcement, the children required the fewest trials to meet the criterion, but when verbal reinforcement was coupled with smiling, the number of trials was only slightly reduced from that which occurred with only verbal reinforcement.

Somewhat different results have been reported by Allen (1963), who compared the effects of the following four types of reinforcement on performance in the marble-dropping task: colored photographs of *E* in poses comparable to those occurring during the delivery of social reinforcement; a small light; verbal statements of praise; and the typical condition in which *E* was present and made supportive comments. The increments in rate of response over a base-rate period were approximately the same for the last three conditions, but decrements in performance were found in the first condition. Until data are available from additional studies it is impossible to provide a satisfactory interpretation of these results.

B. Differences with Age

It is a common assumption that as children grow older they rely less on social reinforcement as a means of guiding their behavior, and more on direct information that is a consequence of their response. Two similar studies (McCullers & Stevenson, 1960; Lewis, Wall, & Aronfreed, 1963) have tested this assumption by comparing the performance of preschool or early elementary school children with that of older elementary school children in a probability learning task. Correct response was indicated by social reinforcement or by a signal (marble or light). Social reinforcement resulted in significantly higher levels of performance in the younger groups than did the presence of a signal, but there were no differences between the two conditions for the older children. Thus, depending upon the child's age, social reinforcement may or may not be an effective means of increasing the child's rate of learning.

VII. Conclusion

This is the picture at the end of 1963. In some places the delineation is very rough; in others the details are more clearly visible. The picture is certainly complex. The literature on social reinforcement has grown rapidly and there is every indication that it will continue to do so. This is an important area of research, and when we have a firmer grasp of the operation of social reinforcement we will be able to offer a more satisfactory theory of socialization and development than has previously been possible.

There are many aspects of the problem which require special attention. There is too little information about the reliability of the tasks used and the correlation between the different measures of the effectiveness of reinforcement. Practically all our information has been based on the observation of children dropping marbles into holes in a container. There have been positive consequences of adopting such a simple task, but it is now important that the studies be extended to include more complex and longer tasks. What are the differences among adults which determine whether they will be effective in modifying children's performance with social reinforcement? What personality characteristics other than dependency and anxiety are related to children's susceptibility to social reinforcement? Institutionalization and isolation clearly affect the child's response to adults. What are the differences between these two conditions, and, importantly, how do the conditions of reduced stimulation come to enhance the effectiveness of social reinforcement? Why does an apparently "neutral" condition in which the adult does not reinforce the child sometimes result in higher levels of performance than are found when the adult does reinforce the

child? There are many questions. Trying to answer them will be tedious, but the results of studies of social reinforcement are so frequently positive, and often surprising, that the experimenter should meet with frequent reinforcement for his efforts.

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DELAYED REINFORCEMENT EFFECTS

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I. Introduction

For a long time psychologists have had both a practical and theoretical interest in the effects of rewards on behavior. Many individuals (researchers, parents, teachers, lawyers, salesmen, to mention but a few) concerned with the everyday problems of motivating the behavior of others, have demanded answers to questions relating to the effects of various incentives under different conditions. Learning theorists generally recognize the importance of reward in the learning process.

The manner in which rewards influence behavior is indeed complex. The nature of the reward, its size, how it is delivered, the frequency with which it is administered, by whom it is delivered, the circumstances surrounding its delivery, and whether it is delivered immediately after the learner's response, or after a delay interval, all have been shown to be important conditions affecting the influence of rewards on the learning process. This paper is concerned with the effects of the delay of reward, or the time interval separating response from reward. Although some of the more important animal studies will be reviewed, the paper will emphasize research with human subjects (*S*s), particularly children. Throughout the paper, the terms *reward* and *reinforcement* are used interchangeably.

Although special emphasis will be given to the impact of delay of reinforcement on learning, research dealing with individual differences in the ability to delay gratification of desires will also be reviewed. It is believed that an analysis of the characteristics of those who are able to postpone reinforcement in anticipation of long range rewards may yield useful information about the mechanisms involved in learning under delayed reinforcement conditions.

Section II consists of a review of animal studies. It will be seen that most animal experiments are in essential agreement regarding the effects of reinforcement delay. Experimental research with children is reviewed in Section III, and experiments employing adults as *S*s are examined in Section IV. Cross-cultural investigations of children's preferences for immediate and delayed reward are reviewed in Section V. The result of studies at the human level, especially with children, are much more contradictory and difficult to interpret. This is due in part to the fact that the experimental conditions prevailing in the experiments with human *S*s differ sharply. Although this point will be discussed in detail in a later section, it seems appropriate to emphasize here that the variables controlling the effects of reinforcement delay in human *S*s are more numerous and interact with many more factors than is the case with infrahuman organisms.

Finally, Section VI consists of a discussion of theoretical considerations and conclusions relating to the research reviewed.

II. Review of Research with Animals

A. Research Involving Constant Delay Intervals

Thorndike (1913) first suggested that the time interval between the response of a learner and the reinforcing state of affairs relates positively to the strength of the connection between receptor and effector processes. Washburn (1926) somewhat later expressed essentially the same notion. Some researchers have employed a constant delay interval, while others have varied the duration of delay in a number of ways. Experiments in which constant delays are used are reviewed in this section.

The early experimental work on the original Thorndike hypothesis was performed with animals by Watson (1917), Warden and Haas (1927), and Hamilton (1929). Watson, and Warden and Haas failed to find significant differences in the rate of learning of rats as a function of time of delay in reinforcement. Hamilton, however, found that performance was inversely related to the delay interval. These contradictory results have been explained by Hull (1943) and Spence (1947) in terms of secondary reinforcing cues which were present to a marked degree in the Watson and Warden and Haas experiments, but were more effectively controlled in the Hamilton investigation. In the Watson study, rats were required to dig through sawdust to find a hole in a food chamber. These animals were permitted to remain in the food chamber pending the delivery of the reward, thus maximizing secondary reinforcement. In the Hamilton experiment the animals were trained in a free choice Y-maze and were kept in a separate chamber while they awaited the food reward.

Hull (1943) developed his formulation of the functional relationship of habit strength to the temporal delay of reinforcement primarily on the basis of an experiment by Perin (1943). Perin found that rats could not learn an instrumental bar-pressing response if delays of greater than 30 seconds followed response. Hull (1943) postulated habit strength to be a negative growth function of the time between reaction and reinforcement. Hull (1952) later suggested that there are two types of delayed reinforcement. One consists of a chain of responses, in which the reinforcement decreases in strength as it proceeds backward from the reward to the beginning of the response chain. The other case is the single S-R relationship. Since the Hull (1943 and 1952) formulations, many investigators have explored the effects of this variable on animal and human learning.

Most of the more recent work with animals suggests that delay intervals must be shorter than the 30 seconds found by Perin (1943), if the animal is to learn. Grice (1948) found that rats were unable to learn a black-white

visual discrimination problem when delays of reward were greater than 5 seconds. These findings are essentially corroborated by the work of Wolfe (1934), Perkins (1947), and more recently, Ramond (1954).

To summarize the animal research in which constant delay intervals are used, the evidence is consistent in showing that when secondary reinforcement is limited, the effectiveness of the learning of animals is in part determined by the time interval between response and reward, and that delays of greater than 5 seconds are not likely to result in learning.

B. Research Involving Variable Delay Intervals

Several experiments have been performed in which the delay period has been varied. As is apparent from the description of these studies, they differ in the manner in which reward delay is varied. Some involve two manipulanda with different delays associated with each, while others consist of only one manipulandum with responses followed by varying intervals of delay on different trials.

Logan (1952) trained rats in a Y-maze to depress a bar under two conditions of delay, 1 second and 5 seconds. The criterion variable was response speed. Forced trials were used to insure that the animals had equal opportunity with each door. Following this, the bar-delay conditions were reversed so that the bar that was formerly associated with a 1-second delay now became associated with a 5-second delay and the 5-second bar now became the 1-second bar. For the first 80 trials, *Ss* responded faster to the short-delay bar. Also, *Ss* indicated a preference for the short-delay bar in free choice trials. Additionally, response speeds to the short-delay bar decreased when the conditions were reversed. Although Logan's *Ss* did not show an increase in response speeds when the conditions were reversed on the long-delay bar, Harker (1956) in a similar experiment found the opposite change in response speeds on the part of his *Ss*. In other words, Harker found that there were increases in learning efficiency when the shift occurred from the initially less favorable to the more favorable condition, but no decrease in efficiency when delay conditions shifted from a more to a less favorable condition.

Ferster (1953) has demonstrated that animals can be trained to perform under delay conditions. Pigeons were trained to peck under zero-delay conditions, after which time a 60-second delay interval was introduced following *Ss*' responses. Pecking stopped. Delays of gradually increasing length were then reintroduced as the pigeons acquired stable pecking response to the new condition. Normal response rates finally were obtained at 60-second delays. An interesting parallel exists between the results of Ferster's study with pigeons and one recently performed by Terrell and Ware (1963) with children.

This similarity, involving learning to perform under delayed reward, will be discussed in a later section of this paper.

Several investigators have varied delay of reinforcement in order that *S*s may be presented with one delay interval on some trials and a different delay period on other trials, comparing such variable delayed reinforcement conditions with constant delay and immediate reinforcement groups; e.g. Logan *et al.* (1955), Scott and Wike (1956), Peterson (1956), Logan *et al.* (1956), and Kintsch and Wike (1957). In general, these studies show greater resistance to extinction following both varied and constant delay than following no delay.

Crum *et al.* (1951) varied delay by presenting a group of *S*s with zero delay on half of the trials and a 30-second delay on the other half of the trials. A second group of rats had zero-delay conditions on all trials. The variable-delay group resisted extinction more vigorously than did the zero-delay *S*s.

It should be mentioned that although the Logan *et al.* (1955) experiment failed to find greater resistance to extinction in varied-delay conditions when the delay was 9 seconds, Logan *et al.* (1956) later confirmed the Crum *et al.* (1951) results, where variable delays of zero and 30 seconds were used.

Pubols (1958) has presented evidence suggesting that the greater resistance to extinction under variable-delayed reward conditions may be due not to the *variability* of delay, but to delay per se. Pubols' animals were run a constant number of trials in learning a position discrimination in a single choice maze. The positions were then reversed. Each of four delay groups during learning, 2, 4, 8, and 16 seconds, was paired with the same four delays during reversal. Pubols found that the greater the delay during acquisition the greater the resistance to extinction where the latter is measured in terms of the number of perseverative errors before the first reversal response. Pubols interprets this finding as inconsistent with the Hullian (1943) prediction that shorter delays during acquisition should produce greater resistance to extinction because of the greater reaction potential presumed to accumulate as a result of shorter delays. Pubols interprets his data as being consistent with Skinner's (1938) view that resistance to extinction should be positively related to the similarity of conditions that exists between acquisition and extinction. This interpretation has also been advanced to account for greater resistance to extinction following intermittent than continuous reinforcement. Logan (1960) suggests that the same principles regulate resistance to extinction in partial reinforcement and variable delay reinforcement conditions.

In a recent study supporting the work cited above, Sgro and Weinstock (1963) found that rats ran faster during extinction trials following 15-second delays than two other groups rewarded after delays of 0 and 7.5 seconds, respectively, during the pre-extinction runs.

C. Escape Behavior Under Delay Conditions

Fowler and Trapold (1962) found that runway speeds were slower the greater the delay of shock termination after *S*s reached the goal box. Thus the conclusion seems reasonable that escape behavior in a delay situation is governed by the same principles as those behaviors associated with delayed appetitive rewards.

In summary, the research with animals, in which secondary reinforcement effects have been effectively controlled, shows that acquisition is related to delay of reinforcement in a negatively accelerated decreasing manner. There is some evidence to suggest that animals are able to adapt to increasing periods of delay of reinforcement. Resistance to extinction is, in general, greater following constant and variable delay of reinforcement than immediate reinforcement. Finally, there is some evidence that in the experiments showing greater resistance to extinction following variable delayed reward, it is not the variability of the delay of reinforcement but rather the delay per se which brings about greater response perseverance under this condition. It is important to note that these findings are essentially consistent, without regard to the kind of tasks required of *S*s, the animal used, or other experimental variables which, as the next section reveals, have considerable bearing on the impact of reinforcement delay at the human level.

III. Research with Children

A. Experimental Studies

The research with children involving the delay variable has consisted of many kinds of experiments in which numerous tasks, procedures, and response measures are employed. Although the data in general show reinforcement delay to have an adverse effect on learning, it will be seen that interpretation of these data is complicated by the fact that the delay variable interacts with a number of other dimensions.

Spence's (1947) hypothesis relating to the deleterious effect of reinforcement delay in animal learning emphasized the disruptive impact of competing responses made by the animal while awaiting reinforcement. There is some evidence relating to the usefulness of Spence's notion at the human level. Lipsitt and Castaneda (1958), and Lipsitt *et al.* (1959) show that children in general develop preferences for and respond more quickly to a stimulus which has been associated with an immediate reinforcement than to one with which a reinforcement delay has been associated.

Lipsitt and Castaneda (1958) compared the relative effectiveness of a zero and a 7-second delay on choice behavior and response speeds in an instrumental learning experiment. The *S*s were preschoolers, with an age range of 4.2 to 5.8 years. The apparatus consisted of a black plywood box, $24 \times 7 \times 14$ inches. Two jeweled reflectors, arranged vertically, one red and one green, and a response button were mounted on the apparatus. The rewards were marbles which *S*s were permitted to exchange for a toy when the experiment was over.

The children were given a total of 60 trials. On the first trial of each block of 4 trials, *S*s were given a free choice of the stimulus to which they preferred to respond. The immediate and the delayed reward lights each appeared two times in each block of four trials. Lipsitt and Castaneda found that *S*s responded significantly more frequently on the free choice trials to the light with which immediate reinforcement was associated than to the one associated with reinforcement delay. This difference increased significantly with trials. Response speeds, although somewhat faster to the immediate than to the delayed stimulus, were not significantly different. Lipsitt and Castaneda cite the presence of secondary reinforcing cues (the light remained on during the delay period) as being possibly responsible for the nonsignificant response speed difference. Terrell and Ware (1961), in a discrimination learning study, failed to find preferences for stimuli with which immediate (as opposed to delayed) reward has been associated. They attributed the difference between their study and that of Lipsitt and Castaneda to the fact that *S*s in the latter experiment had 60 trials, several times more than those of the Terrell and Ware study.

In a later experiment, Lipsitt *et al.* (1959), using a similar apparatus to that employed by Lipsitt and Castaneda (1958), tested the effects of delayed reward (6 seconds) pretraining on the subsequent learning of a simultaneous discrimination task. Again, *S*s were preschoolers, mean age 4.8 years. They were assigned to two groups during pretraining. The experimental *S*s were given immediate reinforcement to one color and delayed reward to another, while control *S*s were rewarded immediately to both colors. Each color was presented 20 times, making a total of 40 trials.

During pretraining in this study, the control *S*s responded significantly more rapidly to the immediately rewarded stimuli than did the experimental group to either the immediate or delay lights. After the first block of 5 trials, moreover, the experimental *S*s responded more rapidly to the immediate than to the delay light. The authors suggest that the use of the free choice trial procedure in the earlier study, omitted in the Lipsitt *et al.* experiment, may have accounted for the difference in response speeds in the two studies. An interesting side light of the pretraining trials analysis shows the control group *S*s responding more rapidly to both lights than the experimental group

did to the immediate light, a finding which the authors suggest is due to the generalization of delay effects in the experimental group from the delay light to the immediate light.

Lipsitt *et al.* (1959) also tested for the effects of the delayed reward pretraining on the subsequent learning of a simultaneous color discrimination problem during which time the immediate reward stimulus of the pretraining session was now the correct stimulus for all children. During the discrimination problem, the two colors appeared together with position counterbalanced from trial to trial. The *S*s were rewarded immediately when correct responses were made. They received nothing following incorrect responses. The experimental groups made significantly more correct responses on the simultaneous discrimination tasks.

The faster responses to the immediate stimulus in the pretraining session can be interpreted as support for Spence's (1956) response competition hypothesis. Apparently, *S*s made irrelevant responses of a sort, internal or overt, during the delay period which served to reduce their speed of response in comparison to responses to an immediate reinforcement stimulus. However, despite the presumed effect of response competition during pretraining, apparently the pretraining experience served to sharpen *S*s' capacity to distinguish the immediate from the delay stimulus, a skill which transferred to the subsequent discrimination problem situation, and became manifest in the superiority of the experimental over the control group in the second part of the experiment.

Lipsitt *et al.*, (1959), following a suggestion emanating from the work of Pubols (1956), Reid (1953), and Wyckoff (1952), proposes that the experience of the experimental group *S*s with both immediate and delayed reinforcement during pretraining, as opposed to experience with only one reward condition, immediate, for the control *S*s, resulted in the development of superior "orienting" habits on the part of the former.

Erickson and Lipsitt (1960), in a study of the relative effects of reinforcement delay on simultaneous and successive discrimination learning, suggest that competing responses during delay may have been reduced by the development of superior visual orientation by *S*s as a result of the experimental procedures employed. They found no main-effect differences in three reward delay intervals, 0, 3, and 6 seconds on simultaneous and successive discrimination learning of fourth graders. The *S*s oriented toward the light throughout the delay period, thus possibly neutralizing the tendency for competing responses to interfere with learning. The present writer suggests that the difference in age of *S*s in the Lipsitt *et al.* (1959) and the Erickson and Lipsitt (1960) experiments may have been an important factor in determining the differences in the two studies with respect to the "visual orienting" factor. The procedures of the two studies were very similar, particularly those which would be expected to affect postural and visual habits of *S*s during the experiment. It may be

that older children are better able to neutralize the effects of competing irrelevant elements in the learning enviroment, particularly if the experimental conditions also require *Ss* to attend carefully to the task. There is some evidence to support this suggestion. Brackbill and Kappy (1962) found no difference in 0-, 5-, and 10-second delays in a two choice discrimination task for third and fourth graders, although retention a day later favored the immediate reinforcement group. Mischel and Metzner (1962) found that preference for delayed reward as opposed to immediate reward is positively related to chronological age ($r = +.65$).

An experiment by Hockman and Lipsitt (1961) suggests that the difficulty of the task is an important factor in determining whether or not reinforcement delay adversely affects learning. Fourth graders learned a relatively simple (two stimulus) discrimination problem as easily under a 30-second delay of reinforcement as under immediate reward. For a more difficult (three stimulus) discrimination task, however, significant differences were obtained as a function of reinforcement delay. It is conceivable that the more complex tasks either themselves generate more competing responses or make it more difficult for the learner to cope with irrelevant responses initiated during the delay interval from other sources as he attempts to focus on the relevant components of the problem.

Rieber (1961) provides perhaps the most direct test of the response competition hypothesis found in the literature, where children are *Ss*. He used an instrumental response (lever depressing). In one group of *Ss*, group DS, the cue (conditioned stimulus) eliciting the conditioned response remained on during the delay period. It was believed that this procedure would maximize the presence of competing cues. For another delay group, group D, the light terminated immediately following the *Ss*' responses. Group IM received immediate reinforcement. Kindergarten children were *Ss*. The reinforcement, a trinket, followed *Ss*' responses in the delay groups by 12 seconds.

Two measures of response strength were employed: starting speed, the interval between the onset of the conditioned stimulus and the beginning of *Ss*' response, and movement speed, the time interval between the beginning and the end of the response. Spence (1956) held that in delayed reward learning, starting speeds are inversely related to the effect of competing responses and that after *S* responds, competing responses are less likely to arise until the response ends. From these assumptions it can be predicted that movement speeds are less affected by response competition than starting speeds.

Within the framework of Spence's suggestions, Rieber (1961) predicted that the responses of group DS would be the slowest of the three groups, group IM the fastest, and group D in the middle. With respect to starting speed, group DS responded significantly more slowly than did Group D, and group D significantly more slowly than group IM. In movement speed, group DS responded significantly more slowly than group D, while groups D and

IM did not differ significantly from each other. Rieber holds that competing responses are aroused in groups D and DS by virtue of the fact that these competing irrelevant responses, along with the conditioned response (lever pulling), are reinforced when the reward is delivered and thereby become conditioned to a set of stimuli present throughout the delay period. These stimuli, of course, include the conditioned stimulus, a fact which makes it possible for the latter to elicit the competing responses. Apparently this is what happens to a much greater degree in groups DS and D, more so in the former due to the fact that the conditioned stimulus remained on throughout the delay period. Rieber accounts for the nonsignificant difference in movement speeds between groups IM and D in terms of Spence's assumption referred to previously that competing responses are less likely to arise after the response has occurred. Still another bit of evidence in support of Spence's (1956) hypothesis is the significant increase in movement speed (and not starting speed) over trials.

Rieber (1964) performed another experiment to test the notion that the adverse effects of delayed reinforcement were due to the association of inhibitory responses with the conditioned stimulus. Preschool children were given delayed reward pretraining, after which they were required to learn either a simultaneous or a successive discrimination problem involving the same stimuli as were used in the petraining session. The *Ss* were seated at a wooden box with three levers which served as the response mechanisms. Above the levers were lights which were the conditioned stimuli. The levers could be depressed 9 inches. A reward cup was situated below the levers. When the levers were depressed in response to lights, a trinket was delivered into the cup. The center lever was used during the 10-trial pretraining session, during which time *Ss* received 5 trials to each of two lights. The two end levers were employed during discrimination learning. During pretraining, Groups I-A and I-B associated the blue light with immediate reward and the red light with a 12-second delay. The light reinforcement conditions were reversed for Groups II-A and II-B. For Groups III-A and III-B neither light was consistently associated with immediate or delayed reinforcement.

During discrimination learning, Groups A learned a simultaneous task, and Groups B a successive problem. For the three A groups responses to the lever under the red light were followed by immediate reinforcement while blue light responses were not rewarded. The B groups learned to depress the left lever when the blue light was on and the right lever in response to the red light. The learning criterion was ten consecutive correct responses.

Rieber found in this experiment that during pretraining there were no differences in starting or movement speeds as a function of reward conditions, when the typical latency measures were used, that is, the latencies of the trials on which the particular reinforcement occurred. However, when the speeds

of response on the trials *following* the delayed trials (FD) were compared with those on trial following the immediate trials (FI), a different picture emerged. Starting speeds thus anlayzed were found to be significantly slower for delayed than for immediate trials. Movement speeds, however, were faster following *delayed* than immediate trials. During discrimination learning, reinforcement conditions had no significant effect, although as was the case in the Lipsitt and Castaneda (1958), Lipsitt *et al.* (1959), and the earlier Rieber (1961) studies, speeds increased significantly over trials.

Rieber (1964) concludes that the "effects of delay are not necessarily the result of the association of competing responses with the conditioned stimulus, but may simply be due to the after-effects of delay from the previous trial." The present writer holds that response competition itself may not be effective until the trial following delay. The difference in the Rieber (1964) experiment and Rieber's (1961) previous work may be due to the fact that *S*s in the former study performed under both immediate and delayed conditions, while *S*s under the earlier investigations learned under either immediate or delayed reinforcement.

Terrell and Ware (1961) performed an experiment as a result of which they suggested that both associative and incentive factors are responsible for the more efficient learning of children under immediate reward conditions. Terrell and Ware employed a discrimination learning setup in which *S*s were required to learn a size and a form problem concurrently. Kindergarten and first graders were divided into two groups. Group I learned the size problem under an immediate reward condition and the form problem under delay, 7 seconds. For Group II, the task-reinforcement combinations were reversed. The reinforcement was a light flash. In the size problem, *S*s were required to push a button to the larger of two cube boxes and for the form task, the correct response was a sphere rather than a pyramid. In a second part of the experiment, a different group of *S*s was required to learn three-stimulus size and form problems, where the correct response in the size task was to the middle sized of three cube boxes, and in the form problem to a pyramid instead of a sphere or a cylinder. In both parts of the experiment, *S*s learned the problem significantly more quickly under immediate than under delay conditions. Terrell and Ware suggest that *S*s' decision time can reasonably be conceived of as a measure of the strength of the association of the correct stimulus-response elements of the task, and that *S*'s general attitude toward the task and the vigor of his responses may be regarded as indices of strength of incentive.

Terrell and Ware (1961) stated that there were suggestions based on casual observation that *S*s responded more quickly (i.e., made decisions as to their choice of correct responses) and more vigorously when learning under immediate than delay conditions. Also, they believed that *S*s attended less well to

the tasks when they were learning under delayed reward conditions. Thus, Terrell and Ware suggest that both associative H, and incentive K, factors are affected by the time interval separating response from reinforcement. Using starting speed as a measure of H, and movement speed as an indication of K, Ware and Terrell (1961) replicated the first part of the earlier Terrell and Ware (1961) experiment with *S*s learning the two stimulus size and form problems under immediate and 7-second delay conditions. Starting time was the interval between the presentation of the task and *S*s' touching the response button; while movement time was that required of *S* to depress the response button the full distance, 6 mm.

Ware and Terrell (1961) again found a highly significant difference in the number of trials to the criterion in favor of the immediate reward condition. Contrary to expectations based on casual observation in the Terrell and Ware (1961) experiment, however, *S*s in the Ware and Terrell (1961) study had faster starting times when learning under delayed conditions. Movement speed differences were nonsignificant.

The faster starting speeds under the delay condition of the Ware and Terrell (1961) experiment, and the faster starting speeds for one group of delay *S*s in the Rieber (1964) study suggest that *S*s may become frustrated when learning under delay conditions and respond impulsively and nonreflectively on the trials when delay occurs, thus retarding acquisition. The Rieber (1964) and Ware and Terrell (1961) experiments combine to suggest that frustration associated with delayed reward learning conditions is manifested by faster (impulsive) starting speeds on the trial on which delayed reward occurs and in slower speeds on the trial following delay of reinforcement. There is other evidence in the literature suggesting that frustration impairs performance on complex tasks, but is associated with increased muscular tension, which in turn produces faster reactions, e.g. Barker *et al.* (1941), Daniel (1939), Davis (1940), Freeman (1930), and Jost (1941).

Both Rieber (1964) and Ware and Terrell (1961) conclude that delayed reinforcement apparently does not affect movement speeds. This conclusion is compatible with the implications of Spence's (1956) response competition hypothesis and the results of a study by Capaldi *et al.* (1962) who found that delayed reinforcement slowed running speeds only in the early section of the alley.

Terrell and Ware (1963) have provided a test of the suggestion that *S*s become upset when learning under delay conditions. Again, kindergartners and first graders learned size and form discrimination problems concurrently. GSR measures as well as behavioral indices of emotionality were obtained during the experiment. Prior to the start of the experiment a basal resistance level was established for each *S* while he was in a relaxed state. Measures

of the magnitude of deflection of the GSR from the basal resistance level were obtained at .3-second intervals. The mean of these measures was used to represent the amount of deflection for any given trial. This calculation was made for each *S* for every trial independently.

Behavioral measures of emotionality include: (*a*) visual orientation away from the task, (*b*) irrelevance of *S*'s verbalizations, (*c*)*Ss*' attitudes toward the task. These measures were obtained by two observers seated at positions where they could easily watch *Ss*.

The GSR measures were analyzed at two stages of learning. Mean GSR changes under the immediate reinforcement condition were compared with those under the delayed condition for the first six trials and the last six trials independently. As expected, for the first six trials the GSR changes were greater under delay than immediate. For the last six trials the difference was also significant, but in the opposite direction. *Ss* also looked away from the task more frequently and made more comments indicating negative attitudes toward the task when learning under the delayed reward condition.

Terrell and Ware (1963) offer several possible explanations for the interaction between the delay condition and stage of learning with respect to the emotionality of *Ss* as measured by GSR. It should be remembered that *Ss* learned the immediate task significantly quicker than the delayed problem, but nevertheless were required to continue to push the button in front of the correct stimulus in the immediate problem. The effects of the greater response competition of the delay condition may have upset the *Ss* in the early phase of learning, whereas in the latter stage of acquisition, the effects of boredom under the immediate reinforcement condition and the possible presence of competing responses which accompanied boredom more than offset the disrupting effects of the waiting period of the delay condition. It is also suggested that *Ss* looking away from the task environment served to allay emotionality caused by response competition or other sources. The fact that there was a general reduction in the magnitude of GSR changes with number of trials, while there was a general increase in number of look-away responses may be interpreted as consistent with this hypothesis.

The Terrell and Ware (1963) experiment also suggests the interesting possibility that children can become conditioned to a constant waiting period under delayed reward learning conditions, a possibility that has some support in the data of the experiment with pigeons by Ferster (1953) discussed in an earlier section.

The GSR data of the Terrell and Ware (1963) experiment relate rather interestingly to the theoretical account by Amsel (1958) of the frustrating effects of delay of reinforcement. Amsel (1958) suggests that *Ss* are likely to experience frustration from delayed reward in the early stages of learning

and "adapt" to the frustration later in the learning. The adaptation to frustration presumably comes about by the conditioning of the frustration to the motor responses required by *S*s.

B. Summary

As mentioned earlier, the experimental work with children is contradictory. Children's learning in general is affected negatively by the interval of time which separates the learner's response from the reinforcement. This general statement means little, however, since the precise effect of delay is dependent upon the sort of response measure employed, the age and ability of *S*, the nature and complexity of the task being learned, and other experimental procedures.

The data from the experimental work with children justify the following tentative conclusions:

1. Younger *S*s experience more difficulty with delayed reward conditions than more mature children. Additionally, *S*s of a given age find learning accompanied by delay of reinforcement more difficult in complex tasks than in relatively simple problems.
2. Preference measures are apparently less sensitive to the effects of delay than are measures of acquisition (e.g., number of trials to a criterion), and starting speeds. Movement speeds are least affected.
3. As is the case with animals, the presence of secondary reinforcing cues in studies employing children masks the difference in effect of immediate and delayed reinforcement.
4. The use of free choice trials in studies in which *S*s have both immediate and delayed reward experience also appears to minimize the difference in impact of reinforcement delay on response speeds.
5. Delayed reward pretraining facilitates subsequent discrimination learning if *S*s have experience during pretraining with both immediate and delayed reward and if the correct stimulus in subsequent learning is the one with which immediate reinforcement was associated during pretraining.
6. Experimental procedures which require *S* to attend carefully to the task tend to eliminate the adverse effect of delay.
7. There is some evidence that any adverse effects of requiring *S* to wait for reinforcement are felt on the trial following delay, rather than on the trial on which delay occurs.
8. When impairment in learning occurs with children as a function of reward delay, it is apparently due more to disruption in the ability of *S*s to develop and strengthen the correct associations, perhaps due in

part to frustration brought about by delay, than to a lessening of incentive motivation. This conclusion contrasts with that of Spence (1956) who contends that delay adversely affects performance through changes in drive, D, rather than habit strength, H.

IV. Research with Adults

Research on the delay variable with adults presents fewer contradictions than do the studies with children. This is true despite the fact that researchers employing adult *Ss* have used different experimental tasks, procedures, and delay intervals. A few experiments have shown that delay of reinforcement affects learning adversely, e.g. Saltzman (1951), Ammons (1956), Greenspoon and Foreman (1956), Bourne (1957), and more recently, Champion and McBride (1962). On the other hand, most studies present no evidence that the time interval separating response from reinforcement is a relevant variable in learning, e.g., Lorge and Thorndike (1935), Saltzman *et al.* (1955), Archer *et al.* (1956), Archer and Namikas (1958), Bilodeau and Bilodeau (1958), Noble and Alcock (1958), McGuigan (1959), Bilodeau and Ryan (1960), Denny *et al.* (1960), and more recently, Bourne and Bunderson (1963). One study by Reynolds and Adams (1953) presents evidence that reinforcement delay actually facilitates learning.

Lorge and Thorndike (1935) found that delayed knowledge of results was just as effective as immediate knowledge of results in a ball throwing task where *Ss* threw balls at a concealed target.

Saltzman (1951) was one of the first to find that in a verbal learning experiment, habit strength is a function of the temporal nearness of the reinforcement to the response. Greenspoon and Foreman (1956) and Saltzman *et al.* (1955), found delay of knowledge of results to be a relevant variable in the accuracy of *S*'s ability to draw lines. Bourne (1957) discovered that college undergraduate students made increasing errors up to 8-seconds delay in a multiple choice concept identification task where the delay in knowledge of results occurred after the experimenter removed a complex stimulus pattern. As we shall see later, Bourne and Bunderson (1963) subsequently found contradictory results in a similar task.

Reynolds and Adams (1953), employing a pursuit rotor task, found superior performance following delayed reinforcement, during both acquisition and a period of protracted nonreinforced transfer trials.

Archer and Namikas (1958), using a motor task, the rotary pursuit problem, performed an experiment which was designed to minimize any adverse effect of delay of knowledge of results. The delay intervals were .0, .2, .4, .8, and 1.6 seconds. In this experiment, after the specified delay, the reinforcement

(a buzzer) was continuous as long as *S* remained on the target. The authors conclude that the learner's knowledge that he is on target is sufficiently motivating as to make any other feedback unnecessary. Archer and Namikas acknowledge that the differences in their study and that of Reynolds and Adams are explainable in terms of the higher level of motivation of the *S*s of the Reynolds and Adams experiment. The latter *S*s were Air Force basic trainees who quite likely felt that their performance would in some degree determine their Air Force career assignment. Archer and Namikas suggest an interesting possibility on proposing that delay of knowledge of results interacts with level of motivation. The evidence relating to the effect of this variable is inconclusive. In view of the somewhat contradictory data available in studies with children, much additional work on this variable is needed.

Noble and Alcock (1958) suggest that whether or not delay of reinforcement is relevant to learning may be contingent upon the complexity of the task. Using a trial-and-error learning arrangement with two degrees of task complexity and six levels of delay of reward, .00, .25, .50, 1.00, 2.00, and 3.00 seconds, Noble and Alcock obtained negative results with respect to both the delay and complexity effects. They point to the uncertainty of the effects of reward delay at the human level until experiments are performed with a greater range of delay and are free of disruptive interpolated activity. Again we see an apparent contradiction of an experiment with children, performed by Hockman and Lipsitt (1961), although the latter experimenters used a greater range of delay. The equivocal nature of the data relating to this variable will be discussed in a later section.

The question of the effect of *S*s' activity during the delay period has been discussed and researched by several experimenters. Saltzman *et al.* (1955), and Greenspoon and Foreman (1956), found conflicting results in that the former demonstrated line drawing to be a function of delay of knowledge of results, while the latter failed to show this relationship. Greenspoon and Foreman suggest that the difference between the two studies is due to the positioning of *S*s' hands during the delay period. The Greenspoon and Foreman *S*s were taught to drawn 3-inch straight lines while blindfolded. After drawing a line, *S* kept his hand and arm in a raised position above the table during the 30-second delay period, after which time *E* returned *S*'s arm to a resting position on a table. This procedure is referred to as "hand maintaining," and obviously was quite tiring. In the earlier Saltzman *et al.* experiment, on the other hand, after drawing the line on each trial, *S* himself immediately returned his arm and hand to the rest position. Bilodeau and Ryan (1960) replicated that part of the Greenspoon and Foreman (1956) study which permitted them to test the validity of the suggestion made by the latter regarding the importance of the hand maintaining activity in determining the effect of delay of knowledge of results. They, contrary to Greenspoon and foreman

(1956), found that delay of knowledge of results had no effect on line drawing skill under either type of hand maintaining procedure.

Although McGuigan (1959) found that the manner of moving the hand after the line drawing response does not affect performance during acquisition trials, the extinction data in his experiment give partial support to the Greenspoon and Foreman (1956) interpretation of the effect of hand maintaining activity. McGuigan suggests that waving the hand after knowledge of results retroactively interferes with the effectiveness of the information on extinction trials.

Champion and McBride (1962) found that activity during the delay period impaired performance on a verbal learning task. Five paired associates were used: needle-thread, sweet-sour, table-chair, sheep-animal, and stem-flower. Latencies of *S*s' responses were the criterion measures. Two delay intervals were chosen, 2 seconds and 5 seconds. One group of *S* read aloud words associated with the stimulus words. For example, for needle, the words sharp, pin, sew, steel, eye, instrument, point, thimble, and sewing were read aloud by *S* during the delay period. Champion and McBride found significant differences both with respect to delay and interpolated activity. Unfortunately, length of intertrial interval was confounded with delay, a fact which makes the delay data suspect in view of the relevance of that variable in some designs (Bourne and Bunderson, 1963).

Champion and McBride suggest that the difference between their results with respect to delay and most of the other experiments involving adult human *S*s may be due to the fact that in other experiments the delay of reward consisted of postponement of knowledge of results in a relatively complex task, whereas in the Champion and McBride study, a simpler task was required and the criterion variable was response latency. Thus, Champion and McBride contend that their study is an analogue of the animal experiments and as such, constitutes a test of Spence's (1956) response competition notion.

Bilodeau and Bilodeau (1958) performed five studies of simple motor learning in which they found that the time interval separating response from reinforcement was not a relevant variable. They also suggest that the length of the interval after reinforcement may be a relevant variable. Bourne and Bunderson (1963) designed an experiment in concept learning in which the effects of both delay of knowledge of results and the interval following reinforcement were measured. Three delay intervals were used, 0, 4, and 8 seconds, and two degrees of task complexity. The Bourne and Bunderson study was essentially a replication of the earlier Bourne (1957) experiment with the post-knowledge-of-results-interval condition added, the latter variable being confounded with delay of knowledge of results in the earlier study.

The Bourne and Bunderson data show no delay of knowledge of results differences nor delay of knowledge of results interaction with task complexity.

On the other hand, post-knowledge-of-results interval was a significant variable. Bourne and Bunderson suggest that the improvement in the performance of their *Ss* as a function of increasing post-knowledge-of-results feedback interval may be due to the greater time *Ss* had for processing the relevant task information in the longer intervals after reinforcement.

In summary, the results of the research on the delay of reinforcement variable at the adult human level generally fail to support the animal work and the predictions of Hull (1943) and Spence (1956) for infrahuman organisms. Most of the studies which show differences in performance as a function of delay of reward are contaminated by the effects of such variables as activity during delay and intertrial interval.

V. Cross-Cultural Investigations

Experimenting within the general framework of Rotter's (1954) social learning theory, Mischel (1958, 1961a,b,c; Mischel and Metzner (1962) has conducted an interesting program of research in Trinidad and Granada relating to children's preferences for larger delayed as opposed to smaller immediate reinforcement. These investigations are relevant because they suggest some of the cultural and subject differences that result in variable response in delayed reward learning.

Mischel's work was directed toward the analysis of correlates and antecedents of children's preferences for immediate versus delayed rewards. His method of eliciting these preferences was simple, yet effective. *Ss* were given an actual choice of either a candy bar immediately or a much larger candy bar after a 1-week wait. Additionally, *Ss* were asked two questions in which similar choices were elicited:

> I would rather get ten dollars right now than have to wait a whole month to get thirty dollars then or,
>
> I would rather wait to get a much larger gift much later, rather than get a smaller one now.

Mischel (1958) found that the choices in these two situations correlated very highly. It was assumed that a subject's choice behavior in a situation involving immediate or delayed gratification is a function of his expectation that the reward will actually be given, plus the value (preference value) of the reward itself. Mischel (1961a) refers to this sort of choice behavior as being a "trust" or belief that the experimenter will keep his promise by giving the reward. Mahrer (1956) has presented evidence to suggest that a person's belief (expectancy) that a promised reward will actually be given, even after a delay interval, influences his choices.

A. Father's Presence in Home

Mischel's (1958) first experiment involved Trinidadian rural children 7 to 9 years old. A relationship was found between preference for reinforcement and whether or not the father was present in the home. Children whose fathers were present preferred larger delayed reinforcement, while those whose fathers were absent from the home preferred smaller immediate reward. Further, Mischel discovered that the preference for immediate reward was stronger in Negro children in Trinidad than in a sample of East Indian children. Mischel assumed that the greater tendency of Negro *S*s to prefer immediate reinforcement was a result of the greater incidence of father absence among the Negro sample.

B. Experience in Delay of Reward

Mischel (1961c) further explored the father-absent variable by comparing Trinidadian children with a similar sample from Granada in the Caribbean. Additionally, Mischel predicted that Granadian *S*s would show greater general choice frequency to delayed reward. This prediction is based on the differences in personality characteristics existing between the two cultures, differences that are related to expectancy theory derived from Rotter (1954). Granadians are known to have a more stable culture than Trinidadians, in that the former have a history of retaining land possessions from generation to generation, value highly delay of gratification of wishes, work for long range goals, and are more inclined to save their resources than are Trinidadians, who are more impulsive, dependent, and more inclined to live for the present. These culture-related characteristics were suggestive of differences in the expectancies of the children of the two cultures that rewards promised at some future time would actually be granted.

The results of this study support in part the earlier Mischel (1958) work in that for 8- and 9-year olds, father-absent *S*s preferred smaller immediate reinforcement, and father-present children tended to prefer larger delayed rewards. However, for 11- to 14-year olds these differences were not found. The predicted differences between the two cultures were found. It is important to note that Mischel's (1961c) procedures and analyses permitted him to test the main effects of the father-absent and cultural variables, uncontaminated by each other.

The differences between father-present and father-absent children are believed to be due to the greater maturity and more satisfactory general adjustment

of the former, making it more likely that those whose fathers are present in the home will develop greater ability to postpone pleasures and to work for future reinforcement, activities which, in general, would be expected to be more characteristic of the well adjusted. Another possibility is that both the father-present and Granada home situations provide more experiences for the child in the postponement of the satisfaction of his desires than do the father-absent and the Trinidad homes.

C. Social Responsibility

Mischel (1961a), reasoning again from Rotter's (1954) social learning theory, hypothesized that socially responsible individuals would be more likely to trust another individual who promises a delayed reward than would less socially responsible persons. Actually, this prediction is based in part on the common belief that socially irresponsible persons are unable to delay gratification of desires (Mowrer and Ullman, 1945). From this assumption, Mischel (1961a) derived the prediction that children high in social responsibility would be more likely to choose a larger delayed than a smaller immediate reward. Social responsibility was measured by an 18-item revised battery from the Social Responsibility Scale developed by Harris (1957). As an additional means of measuring social responsibility a sample of *S*s from a school for delinquents were compared with another group from an elementary government school. Preferences for smaller immediate reinforcement as opposed to larger delayed reward was determined in the same manner as described in the earlier Mischel (1958) investigation. *S*s were Trinidadian Negro children 12–14 years of age, 126 from the regular school and 70 from the school for delinquents.

Compared with *S*s from the regular school, a significantly larger proportion of the delinquent children preferred the immediate reward. Among *S*s from the regular school, those choosing delayed, larger reinforcement, had significantly higher social responsibility scores that did those who preferred smaller, immediate reward.

D. Need for Achievement

It follows from the McClelland *et al.* (1953) concept of *need to achieve* that those with strong achievement needs should have the capacity for postponing relatively unimportant immediate need gratification for much more significant rewards for which one must strive over a period of time. It was on the basis of such an assumption that Mischel (1961b) performed the third in a series of experiments with Trinidadian children involving correlates of preference for immediate versus delayed reinforcement.

Need for achievement measures were obtained in two ways: (a) the McClelland *et al.* (1953) technique, using 5 TAT cards, and (b) a simple question related to aspiration. The latter was accomplished as follows: "Let's pretend there is a magic man. Now let's pretend that the magic man who came along could change you into anything that you wanted to be. What would you want to do?" A one word response to this question was requested by *E*. These responses were categorized in accordance with the need achievement variable.

Both measures of the need for achievement correlated positively with the strength of the tendency to prefer larger, delayed reinforcement to smaller immediate reward.

E. Acquiescence

In the need achievement study described above, Mischel (1961b) was also interested in the relationship between preference for delayed reinforcement and the "tendency to agree" or to acquiesce. Couch and Keniston (1960) identify differences between those with a tendency to agree and those without such an inclination, as similar characteristics to those which Mischel (1958, 1961a) found to differentiate those with a preference for delayed, as opposed to immediate reinforcement. For example, Couch and Keniston (1960) point to the tendency for "yeasayers" to "freely indulge in impulse gratification," a characteristic similar to that displayed by those who prefer immediate reward in the earlier Mischel (1961a) work. "Naysayers" on the other hand, were found to be characterized by responsibility, trust, and strong ego control. Mischel (1961b) devised a simple test of acquiescence which consisted of the following instructions:

> "I have something in mind. I am closing my eyes and concentrating and thinking of it—it is something that you might agree with or that you might disagree with—if you agree, put down a Y for yes; if you disagree put down a N for No."

Mischel (1961b) found the predicted inverse relationship between preference for delayed reward and acquiescence so measured.

The cross-cultural investigations reviewed above, although only suggestive, point the way to important research related to the identification of individual difference variables that cause children and adults to react differently in learning tasks or problem-solving situations involving delayed reinforcement. Any experimenter exploring the delay of reinforcement variable has had his curiosity piqued by the differences he observes in *Ss'* response to delayed reward. And although there is still much to be done in identifying the basic parameters

governing performance in the somewhat ambiguous learning environment accompanied by delayed feedback of information, there is good reason, even now, for exploring the antecedents of subject differences in learning under delay conditions.

In deriving suggestions from research of the type reviewed in this section we assume that preference for larger delayed rewards is correlated positively with the ability to perform under delayed reinforcement in learning situations. Unfortunately, the magnitude of reward variable is confounded with the delay dimension in Mischel's investigations, a fact which, although meaningless within the context of Mischel's purposes, raises questions about the validity of the Mischel data for one interested in investigating subject differences in ability to perform under delayed reinforcement learning conditions. Nevertheless, because of the importance of information regarding individual differences, plus the fact that Mischel's data support impressions about subject differences gained by the writer in his own research, the cross-cultural data reported here are provocative.

VI. Theoretical Considerations and Conclusions

There can be no doubt for anyone carefully reviewing the research on the effect of delayed reward that this variable is related to learning efficiency. As a matter of fact, it would seem that one has only to assume that the reinforcing state of affairs itself is an important aspect of learning to understand that reinforcement delay is relevant, since the longer the time interval between response and reinforcement, the more similar delay of reinforcement is to nonreinforcement.

The research with infrahuman *S*s shows consistently that learning is impossible when reinforcement follows response by more than a few seconds, if secondary reinforcing cues are controlled. It has been suggested by Hull (1943) and Spence (1947) that the fact that any learning at all is possible when the primary reward is delayed is due to the reinforcement provided by secondary cues. Spence (1956) further holds that the S is distracted by his own competing responses which are generated during the delay period, thus retarding learning, or rendering it impossible. Grice (1948) elaborates on the theoretical position of Hull (1943) and Spence (1947) by suggesting that any learning that occurs is due to the immediate secondary reinforcement of the very short-lived (perhaps 5-seconds) internal cues (stimulus traces) representing the correct relationships in the task situation.

The research with animals, for which the Hull (1943), Spence (1947, 1956) and Grice (1948) notions were intended, in general, supports these formulations.

Evidence relating to the validity of the response competition hypothesis at the human level is somewhat equivocal. Rieber (1961) provides perhaps the most convincing evidence of the applicability of the notion at the human level when he demonstrates that response speeds are slower when the conditioned stimulus remains on during the delay interval. Rieber (1964), however, later presents data that lead him to conclude that, initially at least, the retarding effect of delay may not be due to the disruptive impact of competing responses and the inhibitory effect these may have on the conditioned stimulus, but rather to avoidance responses accompanying frustration of *S*.

While it is true that, due to competing responses or other disruptive factors, many of the studies with children show response decrements as a function of delayed reward, it is also apparent that there are conditions which enable the human *S* to counteract any distractions that the waiting period poses for him. Putting it another way, the human learner under some circumstances is able to bridge the delay gap between his response and the receipt of reward or specific information about the correctness or incorrectness of his response. In the simple tasks performed under brief delay conditions, presumably it amounts simply to a persevering of the memory trace regarding preceding stimulus-response events, until the reward or information comes to strengthen the proper connections. For more complex responses and longer delays involving older, more sophisticated *Ss*, the learner may fill the gap by verbalizing the correct stimulus-response relationships vocally or subvocally.

The research reviewed here indicates that how successful the learner is at "gap-bridging" under delay conditions depends upon a host of factors, including the chronological age of the *S*, duration of the delay, the complexity of the stimulus-response relationships holding between the events of the task (task difficulty), procedural matters (especially those relating to the postural and visual orientation of the *S* with respect to the task), the motivation of *Ss* the ability of the *S* to determine on his own whether this response is correct, the duration of the intertrial interval, the activity of *S* during delay , the kinds of experiences *S* brings to the task, particularly the amount of experience with delay of gratification of wishes during socialization training, and a number of personality characteristics suggested by Mischel (1958, 1961a,b,c; Mischel & Metzner, 1962), e.g. the strength of the need for achievement, social responsibility, emotional stability, and the strength of the tendency to acquiesce. The evidence bearing on the effects of subject differences is not as well grounded in systematic research as the information relating to the other dimensions mentioned above. However, the former constitute a group of interesting suggestions for future research.

The remainder of this section will be devoted to a review of the effects of the above variables as they relate to the impact of reinforcement delay. Considerable attention will be given to theoretical implications and needed

research throughout the discussion. This analysis will focus on research at the human level, both child and adult.

A. Chronological Age

Lipsitt and Castaneda (1958), Terrell (1958), Lipsitt *et al.* (1959), Terrell and Ware (1961), Ware and Terrell (1961), and Terrell and Ware (1963) show that the learning of preschoolers and first graders is impaired by increasing periods of delay of reward, while the data of Erickson and Lipsitt (1960) and Brackbill and Kappy (1962) with third and fourth graders show essentially no delay effects during learning. Additionally, Hockman and Lipsitt (1961) report that on easy tasks fourth graders learn effectively under delay and that it is only when the task becomes more difficult that delay interferes. Finally, the fact that the research findings with children are not as consistent as those at the adult level indicates rather strongly that the chronological age of the *S* is an important factor in delayed reward learning.

The picture is confused somewhat by the fact that different tasks and procedures were used by the *E*s. Before definitive statements can be made about the age variable, systematic developmental research needs to be done. Such research should also include studies with preverbal *S*s, not only because of its importance in determining the effect of the developmental variable, but also for its relevance to the more general question of the use of words in "gap-bridging." Also, experimental manipulation of the verbal variable with older *S*s is badly needed.

The writer was unable to find any experiments employing *S*s older than college students and basic military trainees. Nothing is known about the performance of older adults in delayed reinforcement.

B. Attentiveness of *S*s

Erickson and Lipsitt (1960), in finding no delay differences in their discrimination learning experiment with children, suggest that response competition generated during the delay period may have been offset by the fact that *S*s attended to the reinforcement, a light flash throughout the duration of the delay interval. Champion and McBride (1962) found that reading aloud lists of words associated with the stimulus word distracted *S*s, and therefore adversely affected performance under delay conditions. Greenspoon and Foreman (1956) and McGuigan (1959) suggest that motor activity (hand moving) during delay retroactively interferes with the effectiveness of information feedback. Rieber (1961) experimentally interfered with *S*s' attention in leaving the con-

ditioned stimulus on throughout the delay interval as a way of maximizing the frequency of competing responses.

Additional research in which this variable is manipulated both during the delay interval and the intertrial interval would be helpful not only in providing additional evidence relating to the validity of Spence's (1956) competing response hypothesis at the human level but also in providing information relevant to other theoretical formulations concerning the delay of reinforcement variable. As described above, the present writer has taken the position that at the human level the learner must either bridge the time gap with activity in such a way that the correct associations are reinforced when the reward does appear, or alternatively, he must provide his own reinforcement soon after his response or responses. Obviously, the more attentive the *S* is to the relevant aspects of the task during the delay interval, the greater the probability he will bridge the gap in a meaningful way. Apparently Erickson and Lipsitt's (1960) procedures provided for the sort of visual orientation of *Ss* that encouraged attentiveness to the appropriate stimuli of the task and thus resulted in effective gap filling by *Ss* during the delay interval. On the other hand, in the experiments by the present writer and Ware (Terrell 1958; Terrell & Ware, 1961; Ware & Terrell 1961; Terrell & Ware 1963), no special procedures were used to require *Ss* to be attentive to the relevant stimuli of the tasks. As a consequence, the Terrell and Ware (1963) study revealed considerable inattentiveness on the part of *Ss*, a fact which apparently interfered seriously with learning under delayed reward conditions.

Easterbrook (1958), Kausler and Trapp (1960), Brackbill and Kappy (1962), and Renner (1963) offer a similar interpretation in terms of the successful utilization of cues by *S* during the delay interval.

C. Motivation

In all experiments concerned with the delay variable, the present writer has found that a few *Ss* learn more effectively under delayed than immediate reward. On the basis of the discovery by Mischel (1961b) that the need to achieve is related to preference for delayed reinforcement, it is suggested that children performing better under delay conditions are more strongly motivated to achieve and would present more characteristics that have been found to be associated with the need to achieve than would those whose performance is superior under immediate reward. McClelland *et al.* (1953) contend that the need for achievement is essentially a drive to compete with a "standard of excellence," a need which is accompanied by those characteristics that are related to attaining excellence: e.g. conscientiousness, skill, and desire with respect to working for long range goals, and independence. Preliminary studies

testing the above suggestions are being conducted. Although the results are inconclusive at this time, there are suggestions that the expected relationships will obtain.

It is suggested that certain types of highly motivated *S*s will find that extrinisic reward, delivered by the experimenter, is unnecessary or even undesirable. Douvan (1956), Terrell (1958) and Terrell *et al.* (1959) report that differences associated with social class membership lead to differences with respect to the effectiveness of a symbolic reward—that children and adolescents from middle class background prefer to learn for the sake of learning rather than to be given something for learning. Also, Terrell (1959) found that children can learn as effectively from the effects of their own manual manipulations as they can when given specific reward. It is probable that in many of the studies reviewed here, some *S*s were able to provide their own reinforcement, a fact which makes the particular types of rewards used in the many studies unnecessary, and therefore ineffectual, whether they follow the response immediately or after a delay interval. In other words, it is probable that the major source of reward of some *S*s, those whose reward consists essentially in knowing that they have made the correct response, is not closely related to the reward manipulated by *E*. It is believed that many studies showing no differences in performance as a result of delayed feedback may be attributed in part to this phenomenon.

D. Intertrial Interval

In general, researchers do not report the duration of the intertrial interval, a potentially important variable in research devoted to delay effects. From this it can be assumed that this variable is often confounded with the delay effect. Bourne and Bunderson (1963) in one of the best controlled experiments dealing with delay find that the length of intertrial interval is positively related to learning efficiency and task complexity. Delay differences had no effect. Bourne and Bunderson use these data to support their conception of problem solving as an information processing activity. They reason that learning is relatively unaffected by delay of information feedback if the learner has sufficient time following reinforcement to sort out relevant data, and to select those events that are crucial to solution of the task. It should be pointed out that Bourne and Bunderson's explanation is not inconsistent with Spence's response competition hypothesis. They simply suggest that, if the conditions are conducive to such activity (i.e., if there is sufficient time between trials) the sophisticated human learner has the capacity for offsetting the disruptive effects of competing responses by sorting them out of the total repertory of responses available to him.

The Bourne and Bunderson experiment suggests that the error of numerous *Es* in not controlling intertrial interval is a serious one indeed.

E. Important Research Needs

Numerous deficiencies exist in our understanding of delay of reinforcement effects, especially at the human level. Data relating to the following issues and questions are sorely needed.

1. What is the effect of variable delay of reinforcement at the human level? Will the results of research with children and adults support the data at the animal level which suggest that the impact of variable delay, in terms of resistance to extinction resembles that of partial reinforcement? This question has general theoretical significance.

2. Experiments with animals, children, and adults on learning to learn under delay conditions constitutes one of the most interesting areas in need of additional research. The Ferster (1953) and Terrell and Ware (1963) studies suggest that experience with delay will improve performance under delay conditions. Renner (1964) also points to this as one of the important questions in need of further analysis.

3. The relationship between task complexity and delay is not clear. Available data hint that task difficulty interacts with delay for younger learners, less so at the older age levels. This interaction may be regarded as consistent with the proposition that *Ss* are faced with a problem of filling the gap of delay with associative or cognitive activity which is meaningful to the task, but which may be in competition with irrelevant cues and responses generated by the delay. Viewed in this light, it is reasonable to assume that older, more sophisticated *Ss* are better equipped to solve difficult problems under delay than are the less sophisticated. It is also not unreasonable to assume that with tasks of exceptional complexity and delays of great duration even very mature, able learners may be unable to fill the delay gap meaningfully.

4. The generality of the data on delay are limited in that most experiments involve tasks which are very simple, and delays which are of extremely short duration. The fact that the research performed thus far is limited to short delay intervals is understandable. Until recently, there was no research at all with human *Ss* in which reinforcement delay was studied. Studies employing longer delays would be particularly important in experiments which are designed to maximize effective learning under delay conditions. Such experiments would make use of the variables already known to facilitate performance under delay conditions, e.g., procedures insuring attentiveness and proper visual orientation of *Ss*.

5. More research is needed on the effect of intertrial interval. Bourne and Bunderson (1963) show that this variable is important for adults in concept identification tasks. Is this variable equally important for children? Interesting possibilities exist for testing (with children) Bourne and Bunderson's assumption that the intertrial interval provides the learner with an opportunity to process the information.

6. It is clear that much research is needed relating to *S*'s activity during the delay interval. Experimental manipulation of cues relevant to the solution of the problem would throw additional light on the role of appropriate use of cues on performance in delayed reinforcement.

7. Studies are needed which determine whether or not the effects of delay of reinforcement vary with the *type* of reinforcement. Particularly interesting is whether or not delayed information feedback of the type employed in much research with adults has the same effect on learning as delayed discrete visual or auditory stimuli. The literature does not provide an answer to this question.

8. Further analysis of subject differences between those who perform better in delay and those whose performance is superior under immediate reward should prove valuable. Such research may reveal how learners make maximum use of cues during the delay period.

F. Conclusion

In conclusion, much research on the delay of reinforcement variable is needed. Delay affects the learning of animals, children, and adults. But delay does not operate in isolation of other dimensions. Theoretical accounts of the delay variable at the infrahuman level, while generally compatible with the data from animal studies, cannot possibly be expected to account for the infinitely more complex behavior of human *S*s without extensive elaboration. Spence's (1956) response competition hypothesis has provided a most useful framework for many who have experimented with human *S*s, both children and adults. Apparently competing responses can impair learning. Detailed questions of how and under what conditions they interfere and how the learner can neutralize their effects need to be taken into the theoretical accounts of the impact of delay of reinforcement at the human level. The writer questions the theoretical usefulness at the human level of the older concept of secondary reinforcement as a means of accounting for the occurrence of learning under delay conditions. Certainly the meaning of the concept must be altered significantly so that it represents all cues available to the human *S* during the delay interval—those that may have been associated with the reduction of a primary drive as well as innumerable others, some of which may be response-produced, essential to the solution of the problem.

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A DEVELOPMENTAL APPROACH TO LEARNING AND COGNITION[1]

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[1] This chapter is dedicated to the memory of Professor Heinz Werner, who was my teacher. His influence on this work is apparent.

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I. Introduction

A. Rationale for a Developmental Approach

Developmental psychology deals with the investigation of behavioral similarities and behavioral differences occurring through ontogenesis. A required assumption of developmentally oriented approaches is that there are correlations between *stage, state, level, period, age,* etc., of the organism and its observable behavior patterns. The word correlation is deliberately chosen because no causality is implied between the designating terminology of ontogenetic status and behavior. If the designating terms are to represent more than descriptive categorizations, that is, to be assigned theoretical properties, this will have to be accomplished within the framework of a developmental-experimental research program. Kessen has recently discussed some of the formal problems involved in the transition from descriptive categorization to theoretical characterization (1962).

Another required assumption of developmental psychology is that there are changes in behavior which are, in general, directional, and in some senses not reversible. The acquisition of certain kinds of language skills would exemplify such a unidirectional change. These *developmental* changes are assumed to alter the central state of an organism, such as the maturing child, and are not governed by the rules which apply to the acquisition and extinction of conditioned responses. They constitute changes that are assumed to alter the fashion in which the maturing child defines and orders the world in which he functions. Such changes in central state would affect the acquisition of new responses and alter the character of the learning process. The author assumes (Gollin, 1956, 1960a,b), as do Bruner and Olver (1963, p. 126) ". . . that associations do not just happen, that they are governed by certain rules, and that these are the result of certain rather complex transformations imposed on data by active, collective, limit-bound, talking organisms."

At this point a distinction should be drawn between child psychology and developmental psychology. The developmental psychologist functions primarily within the framework of the concept of unidirectional change. If one's interests, on the other hand, are directed toward the functioning of this or that child, or involve the use of the child subject for the test of this or that aspect of theory, both perfectly legitimate enterprises, one is working within the framework of child psychology. If one adopts a developmental orientation, the two scientific functions may still be carried out, but attention is also, and perhaps primarily, directed toward *comparisons* of individuals representing different ontogenetic periods. Developmental psychology is in essence a compara-

tive psychology which is concerned with within-species comparisons and with the succession of behavior patterns throughout the life span.

Developmental psychologists are likely to have an affinity for that class of theory described by Hebb (1963, p. 16) as: ". . . theories real or potential, present or future, which deal with an interaction of simultaneously present representative or mediating processes in control of behavior, as well as sensory-central interactions." This type of conceptual scheme, which attempts to analyze the complexity of the central process, may be less attractive to the child psychologist.

Within this framework of a central process theory a major objective of developmental psychology would appear to be the specification of the orderly, progressive changes in central representation or mediation which occur in the course of ontogenesis. A primary task of developmental research then is to provide observations which will be useful in clarifying the character and properties of central processes and of establishing their role in the determination of functional relations between stimulus events and response events throughout development.

The idea of differential central mediation is implicit in Lashley's (1929a, p. 536) discussion of the evolution of simple and complex habits. He felt that there was little evidence that evolution brought about any important changes in the rate of formation of simple habits. Such was not the case, however, with respect to the formation of more complex habits where there is a consistent rise in the limits of training associated with ascent in the phylogenetic scale. An analogous situation prevails in human ontogenesis. Immature and mature subjects are not likely to differ much in rate of simple learning. However, as task demands become increasingly complex, functional differences are likely to become more and more striking. Hebb, in writing about the problem of differential central mediation (1958, p. 454), has noted: "When the adult chimpanzee has finally learned to discriminate a triangle from a circle, it has perceived much more about the triangle that the rat has; when the human infant has passed through the stage of primary perceptual elaboration, he can respond to relations that lower animals cannot; but the fact remains that in either case the lower animal gets there first in a simple learning task."

Perhaps the most relevant recent examination of the issues pertinent to the present discussion is found in Hebb's chapter on the development of the learning capacity (1949, pp. 107–139). He points out that most investigations of learning are really investigations of transfer effects (see also Hebb, 1958, pp. 454–455). It is important to distinguish between specific transfer effects, and the effects upon behavioral development of more general, nonspecific experience. The former, specific effects are pretty well covered by the word *learning* in its routine usage. The latter effects, deriving to a great extent from general afferent stimulation, fall in an area of experience in which the

word *learning* is not usually applied. The effects of extended sensory deprivation upon behavior and upon the neural substrate in early ontogenesis (e.g., Riesen, 1960, 1961), as well as the changes in perception and cognition observed in adults after less extended periods of sensory restriction (e.g., Kubzansky and Leiderman, 1961) are indicative of the importance of generalized activation. The word *learning* has proved to be a stumbling block, for as Hebb (1963, pp. 22–23) has pointed out:

> " 'Learning' is indeed a loaded term and a multivalent one: Communication perhaps will not be possible until we start using special terms for its various aspects, including particularly (for the benefit of learning theorists as well as nativists) the nonspecific organizing effects of sensory stimulation upon neural development and integration during the period of growth. For the present, at least, we may note that the interactions of experience with the genetic and nutritive factors have become really inextricable. It is no longer possible to distinguish sharply between constitutional and experiential factors in the development of behavior."

Realistically, then, we cannot deal with naive organisms. Any organism comes to the experimental or testing situation with complex dispositional tendencies. The degree of control we can ever hope to establish over the matrix of contributing factors described by Hebb is limited. His obvious, but often disregarded, point is that what is learned is in terms of what is perceived; what is not perceived cannot be remembered. One can hardly construct a theory of learning from the data of maturity only. There must be a serious risk that what seems to be learning is really half transfer. Hebb quotes Woodworth's phrase that all perceiving is "schema with correction." He goes on to emphasize the importance of early established perceptual habits for later learning. He distinguishes two kinds of learning. One type is exemplified by the newborn, and by the visual learning of the adult reared in darkness or after removal of congenital cataracts. This "first" learning is described as slow and inefficient, progressing by small increments, and as quite different from "mature" learning which is frequently insightful.

Hebb notes one qualification to the above description, a qualification which stems from phylogenetic comparisons. In lower species first learning seems to be rapid. For example, in the area of pattern vision, rats reared in darkness catch up quickly with normally reared controls; primates, similarly treated, require weeks or months to approach normal pattern discrimination. The higher species are capable of more complex relational learning—simple relationships are learned with comparable efficiency by lower and higher species. Hebb's discussion suggests that different sets of functional relationship statements are required for the description of first learning and of later learning, and for the description of the learning of lower, and of higher species. Also indicated,

by implication, is the requirement that research capitalize upon the response and apprehension capacities of organisms, and that research deal with problems other than those arising from *one-kind-of-learning* theories. Such research need not be system oriented but ought certainly to be problem oriented. The problems arise, sometimes, from "theoretical" considerations, but, to a greater extent, from data which do not readily fit extant explanatory efforts. The developmentally oriented investigator, particularly in the areas of cognition and learning, is strategically situated to deal with many of these issues.

Hebb might have been the *founding father* of the research strategy that is described below if he had only made explicit the possibility that contemporaneous perceptual and/or cognitive structures influence the course of modification of behavior, the acquisition of new responses, and, indeed, learning in general. Piaget (1950, 1952) and Werner (1937, 1948, 1954) have stressed this aspect of psychological functioning. Werner, in his genetic psychology, as well as in his microgenetic psychology, has sought to make explicit the contribution of contemporaneous organization to response and the successive availability during ontogenesis of varying central dispositional systems to respondents. It is not the specifics of Werner's position which are important for the present discussion, but rather the way in which he has set the problem.

B. Some Objections to a Developmental Approach

Before discussing the kind of research strategy and tactics which the developmental orientation that has been described would seem to entail, it might be worthwhile to review a number of factors which have contributed to a tendency to avoid developmental work outside the confines of specific longitudinal programs.

There is, first, a tendency to avoid even the word *developmental*. Apparently, reluctance to employ it is associated with a fear that its usage involves the introduction of metaphysical notions which are, at best, obscurant. While it is true that psychological developmental formulations have from time to time suffered from abstruseness, from empirically unsupportable abstractness, and from a tendency to rely heavily on response-inferred constructs, it does not follow that developmental formulations need to be this way. Certainly, developmental ideas have been fruitful for the biological sciences, particularly in areas such as embryology (Weiss, 1939). Recent discussions by Kessen (1962), Bruner and Olver (1963), Gollin (1960a) and others contain guides for developmental formulations which avoid many of the objections that have been raised in the past.

There is, also, reluctance to employ developmental ideas among those adherents of behaviorism who are confident that the variables which constitute the

manipulative array of learning theories are sufficient to account for all those behavioral changes, and ongoing and contemporary behavior characteristics, which are observable over the life span of man. We are all familiar with Watson's famous . . . doctor, lawyer . . . beggar-man and thief . . . statement, which in many senses has served as a defining dictum for many psychologists concerned with the behavior of children. His even more radical assertion (1928, p. 28) regarding the nature of the neonate: "The behaviorist finds that the human being at birth is a very lowly piece of unformed protoplasm, ready to be shaped by any family in whose care it is first placed" would find few proponents at present, but the definition of the problem in Watsonian terms is still very much alive. For example, a similar view of the organism's *contribution* to behavioral change has recently been presented by Skinner. He has written (1963, p. 507):

> "Whether an organism can solve a problem in this sense is as much a question of the program through which it passes—and the skill of the programmer who constructed it—as of any so-called problem solving ability . . . Apparent differences in problem solving ability among species or among organisms of different ages or other properties within a species must be interpreted accordingly. Solving a problem, like learning, is again often attributed to an inner system, although the supposed inner processes, like the facts they explain, are more complex. Those committed to sequestered faculties and thought processes are not likely to feel at home in an analysis of the behavior itself and may, therefore, find it inacceptable as an alternative enterprise."

It is apparent that for researchers of the Watson-Skinner tradition the stimulus program, or perhaps on occasion the stimulus programmer, is the important factor. The living substance, be it animal, or man, or unformed protoplasm, would seem to be incidental. There is no discernible reason for researchers of this tradition to assume either a comparative, or a developmental orientation. To paraphrase Skinner, those committed to sequestered programs and programming are not likely to feel at home in an analysis of behavior in which organisms and organismic manipulations play a central role and may, therefore, find developmental and comparative research inacceptable as an alternative enterprise.

One further reservation which is sometimes mentioned with regard to developmentally oriented research arises, apparently, from a feeling that the problems of developmental psychology are divorced from those of "general behavior theory." This alleged separation is assumed to detract from the "experimental" nature of investigations conducted within developmental frameworks. It is not always easy to determine just what the phrase "general behavior theory" represents. However, there appears to be a notion abroad that unless experiments

are conducted as tests of hypotheses deriving from the "theory" they are not quite as respectable as they might otherwise have been. This notion has been expressed in various degrees by McCandless and Spiker (1956), by Russell (1957), and more recently by Zigler (1963). Russell (1957, p. 169), referring to experimentalists who have somehow departed from the "true" path, has written: "They solve the problem of integrating the experimental and developmental orientations by stripping the former of all but its methodological essentials, and using it as a tool in the service of their developmental interests." It seems strange to have to emphasize that the *experimental method* is just that, a method for obtaining observations in the service of some interest. The standard definition of an experiment is: "an operation carried out under controlled conditions in order to discover an unknown effect or law, to test or establish a hypothesis, or to illustrate a known law" (*Webster's Seventh New Collegiate Dictionary,* 1963, p. 293). The operations utilized in obtaining the observations determine the experimental nature of a scientific enterprise, not whether a specific hypothesis is being tested, or whether the intent of the manipulation is that of inquiry. So long as there are no violations of the rules of experimental procedure it is just as much an experiment if it serves developmental interests, the needs of learning theorists, the problems of physiological psychologists, or any other observational exercise in which it is feasible to manipulate systematically some variable or variables under controlled conditions.

The following section presents the outlines of a research strategy directed at the experimental analysis of developmental problems.

II. The Research Strategy

Researchers who wish to deal with the ontogenesis of behavior confront many of the same misunderstandings and doubts that are faced by workers in the sister discipline of comparative psychology. A recent paper by Bitterman refers to some of these difficulties. He writes that when he proposes to do comparative research he frequently runs into the query: "How do you know your measures are comparable?" The questioner assumes that he plans to compare animals of different species in terms of absolute performance and that he further plans to infer differences in ability from the performances. Bitterman writes (1960, p. 706): ". . . . and he wonders, then, how I can ever be sure that differences in performance *are* due to differences in ability rather than to sensory, or to motor, or to motivational differences." Bitterman points out that he has no intention of comparing absolute scores in a standard apparatus. Rather, his goal is the discovery of functional relations. He recognizes that *control by equation* is an unlikely achievement but that there is a likely alternative, *control by systematic variation.*

In developmental comparisons, the problem of the relative functioning of organisms at different ontogenetic levels may be dealt with in a similar vein. The aim of developmentally oriented research is not to compare older and younger, or brighter and duller, or mature and immature, or healthy and defective, in terms of performance on particular tasks, but rather to determine the comparative functioning of subjects representing different levels of the above noted organismic dimensions on arrays of tasks. In some instances these tasks may represent a quantity dimension, e.g., tests of pursuit rotor skill under conditions of increasing speed, or facility in serial learning under conditions of increasing list length. In other instances, the disparate developmetal samples may be compared on discontinuous tasks, tasks that do not lie along a discernible continuum, e.g., younger and older subjects might be trained on both a rote learning task and on a task in which insight learning is possible. In effect, the research ought to embody the characteristics of a *levels* $\times$ *levels design*. The organismic[2] dimension ought to vary systematically when the problem calls for such variation. So, for example, one might wish to sample successive ages in 2-year steps. On the other hand, relevant developmental information does not necessarily depend upon successive age sampling. One might choose, within the frameworks of particular problems, to compare preschool age children with young adults. The essence of the developmental-experimental approach is to vary both the stimulus dimension and the subject dimension within the same research context. Suppose there are two groups of subjects, S_1 and S_2, and they are found to manifest different performance characteristics within the *levels* $\times$ *levels* design which has been described. S_1 does not differ from S_2 on the rote learning task but shows very marked differences from S_2 on the insight learning task. The uncovering of both the similarity *and* the difference in performance obviously gives us an order of information about the two groups which is quite different than if we had simply demonstrated that they did or did not differ on one or the other task. What is of special importance in this context is the insight into the functioning of the disparate samples that the combined finding provides. It sets the stage for and points to the direction of further inquiry. In the face of such data, developmental psychologists, comparative investigators, researchers concerned with individual differences, etc., ought to introduce experimental probes which are directed at exploring and operationally defining the *subjects* $\times$ *tasks* relationships. In some cases, the objective will be to determine whether the similarities in performance are alterable, but in most developmental research, the objective will be to determine the extent to which the differences between the groups of respondents are resistant to training efforts designed to eliminate or reduce those differences.

[2] Organismic is used here in the sense of Edwards, A. L. *Experimental Design in Psychological Research.* New York: Holt, Rinehart & Winston, 1960, p. 215.

At this point in a developmental research program, one is confronted by a problem that arises in training experiments in which practice turns out to be ineffective. As Thompson (1962, p. 123) has pointed out, it is difficult to evaluate such experiments since one cannot prove the null hypothesis. That is, one cannot be sure that a greater amount of training, or a different training procedure might not have produced positive results. This presents formidable obstacles to a discussion of developmental changes in maturation-learning terms, or in terms of stages, states, levels, or any other terminology which conveys the notion of some central process or capacity that imparts functional qualities to the S-R relationships recovered from one respondent in contrast to those recovered from another respondent. The problem is particularly acute when theory or previously observed empirical relations lead to the expectation that the respondents in the S_1 group will fail in some task and the respondents in the S_2 group will succeed in that task. The difficulties entailed in the confirmation of the inferred operation of a *limiting factor* or *construct,* a central process which is assumed to impose certain restraints upon behavior (Gollin, 1956, 1960a), are mitigated, at least in part, by recasting the problem. Instead of inquiring whether organisms are or are not *capable* of some performance, the inquiry ought to determine the circumstances which produce or fail to produce changes in behavior. When this is done within the context of the *subjects* $\times$ *task-levels* design, a definition of organismic functioning is accomplished in terms of the experimental manipulations and subsequent performances. If subjects in the S_1 group have not learned a discrimination after 500 trials, while subjects in the S_2 group, for the most part, learn it in a trial or two, it would seem reasonable to entertain some notions about differences in central functioning. If a training variable is introduced after base performance characteristics have been established for S_1 and S_2 and the variable facilitates the performance of the latter group and impedes the performance of the former, once again, it would seem reasonable to regard the sources of difference as arising, in part, from the subjects and not being exclusively definable in terms of the stimulus manipulation or probe selected to reduce or eliminate functional-relational differences which manifest themselves in the initial phases of the behavioral analysis.

The variable chosen as the experimental *probe* will often be selected because of its theoretical relevance or because of its empirical history. When the variable is used in the context we have been discussing, it is not only useful in defining the behavior of organisms in operational terms, but there is a reciprocal service in that the extant theoretical assumptions regarding the role of the variable are subjected to the kind of test not typically undertaken in most behavioral research. The effects of the variable are tested to a greater or lesser extent across the ontogenetic continuum. In this way a developmental analysis of behavior may contribute valuable information for general behavior theory.

When differences are found which are refractory to change, the attribution of these differences to experiential or biochemical or other factors will, of course, depend to some extent on the affinities of the investigator, on logical considerations, and upon other sources of empirically derived knowledge. Perhaps the most important feature of the enterprise is that it is likely to uncover important directions for further investigation designed to define increasingly the organisms whose behavior is being analyzed.

If learning, as Hebb has stressed, does indeed always involve transfer, then, whatever else is at work when learning occurs, the process remains to a great degree a function of the transfer propensities of organisms. Transfer models ought to be employed, whenever possible, within the framework of the *subject* $\times$ *tasks* inquiry. An ideal transfer situation for developmental research is one in which *S*s may be trained to some performance criterion on a base task and then tested on the use they are able to make of that training in other tasks. Illustrative experiments will be presented in Section IV.

No one experiment will necessarily include all the methodological features which have been discussed. Single experiments, which in themselves have little relevance for developmental problems, may assume a great deal of developmentally important meaning, when considered together with the data from other sources of inquiry. Whether or not a particular aspect of research is valuable developmentally, regardless of what other values it might contain, will depend to a great extent on the use to which the information is put. It is important to recognize that whim is involved in the utilization of observational materials; one man's "ruined" experiment may be another's inspiration.

III. Examples of Investigations Containing Properties Useful for Developmentally Oriented Research

A. Lashley's Study of Maze Learning in Rats

Lashley's well-known study (1929b) of rats in which maze learning ability was related to the size of surgically induced brain lesions exemplifies research which is particularly appropriate in the investigation of developmental problems. Lashley manipulated an organismic variable, amount of brain tissue destruction, together with a stimulus variable, degree of maze complexity. Lashley's three-dimensional graph of the relationships between organismic, stimulus, and response variables is reproduced in Fig. 1. The organismic variable is represented along the horizontal axis, the ratio of stimulus difficulty is laid out along the oblique axis, and the response measure (errors) is plotted on the vertical axis. The relationship between organismic condition and task difficulty is readily noted. "The simpler problem offers difficulties which are not much greater for animals with brain lesions than for normal ones; and, correspondingly, the difficulty does not greatly increase with increasing magnitude of brain injury. The

more complex problem, on the other hand, is more difficult for animals with lesions than for normals; and as the magnitude of the lesion increases, the difficulty of the problem becomes progessively greater" (Lashley, 1929b, p. 74).

If Lashley had not varied both organismic factors and task-difficulty factors within the *subjects* × *tasks* framework his data picture would not have been nearly as complete nor as suggestive of some of the later investigations which were carried out.

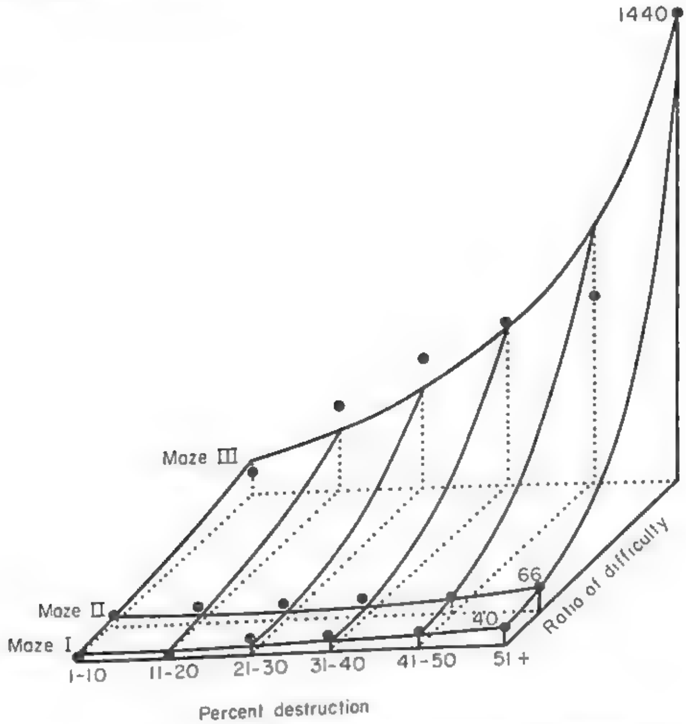

Fig. 1. A three-dimensional graph showing the relationship between extent of brain damage, level of maze difficulty, and performance. (After Lashley, 1929b, p. 74, by permission of the publishers.)

The developmental psychologist concerned with human behavior is not, of course, going to tamper with the physical integrity of his subjects in order to manipulate the organismic dimension. The organismic dimension which he does employ may be as crude or as refined as behavioral and historical ordering techniques permit; it may convey much or little information about his subjects. If it is used in the *levels* × *levels* research context, the investigator will learn more about both his subjects and his selected stimulus variables than other research contexts would permit.

It is interesting to speculate about what might have happened had Lashley's laboratory assistant been careless and allowed both normal and operated rats to become intermingled. Suppose there had been no distinguishing marks on

individual animals to indicate whether a brain lesion had actually been induced, or to what degree it had been induced. Lashley still would have been able to recover a great deal of behavioral information about each rat in the context of the three levels of maze difficulty.

The investigator using human subjects is essentially in the position which would have prevailed in Lashley's laboratory had the surgical history of the animals been lost. However, the investigator of human behavioral development has certain advantages over the mythical situation in Lashley's laboratory. He knows something about his subjects, be it only their age or other general classifying information. He may obtain behavioral data under controlled conditions, or he may establish performance bases and then, within the framework of a transfer paradigm proceed to explore what his subjects are able to do as a consequence of both the classification in which they fall and the special training they have been afforded.

B. McGinnis' Study of Maze Learning in Children

The importance of selecting appropriate tasks for the investigation of the development of cognitive behavior was pointed up in McGinnis' study of the motor habits of young children (1929). She trained her subjects to learn a concealed-cue maze and a pattern maze. During the first trial on a concealed-cue maze, the subject must resort to trial-and-error learning. The maze is so constructed that the subject has no alternative but to rely upon rote learning procedures. By way of contrast, the pattern maze (in this case the Young-Slot Maze) provides cues which a subject may utilize as guides in proceeding from *start* to *goal*. McGinnis found no relationship between first trial performance on the pattern maze and first trial performance on the concealed-cue maze; a relationship was found between first trial performance on the pattern maze and intelligence test scores, but there was none between intelligence test scores and the concealed-cue maze.

It is not surprising that the rote task is unrelated to intelligence measures or to the task which provides perceptual and cognitive cues. It would not be surprising if the rote task did not produce performance differentials between older and younger subjects within the human ontogenetic continuum, nor would it be a startling discovery to find that such tasks do not distinguish among members of different species. It is interesting and useful to locate learning situations in which performance similarity and functional resemblances prevail; but this is only part of the objective of developmentally oriented research. Such findings provide base lines against which to compare performance differentials and potential functional differentiations expected to arise when more complex or demanding learning situations are introduced.

C. The Miles-Ruch Contribution to Developmental Methodology

It is about three decades since W. R. Miles, in the course of delivering his presidential address to the APA, said (1933, p. 105): "I am here simply casting my vote in favor of turning our experimental searchlight clear across the length as well as the breadth of man's life-span." Miles and his students (e.g., Ruch, 1934) conducted experimental probes across ten decades of human life. They studied perceptual and motor behavior, as well as various aspects of verbal learning. Implicit in their approach was the notion that functional relations between stimulus and response events would vary with age-related factors. They assumed that learning must involve changes in nervous tissue and that senescence reflected lowered plasticity of nervous tissue. It was predicted that " . . . aged as compared with young learners should show a greater deficit in that learning which requires extensive reorganization of pre-existing habits than in that learning which makes use of previously formed habits; while that learning which is neither interfered with nor aided by old habits should show an intermediate degree of deficit of the aged" (Ruch, 1934, p. 261). Young (teen-age), middle-aged (34–59 years), and old-aged (60–82 years) groups were tested on direct-vision and mirror-vision pursuit rotor tasks, and on three verbal learning tasks. The three verbal learning tasks included a series of simple, paired associates (MAN-BOY), a series of nonsense associates ($E \times Z = G$), and a series of false multiplication products ($3 \times 5 = 25$). Table 1 shows the results obtained in the investigation. The general expectation that the older subjects would show the greatest learning deficit in tasks requiring reorganization of pre-existing habits was confirmed.

TABLE I

AVERAGE LEARNING PROFICIENCY OF THE THREE AGE GROUPS. THE AGE CHANGES ARE SHOWN IN COMPARISON WITH THE YOUNG GROUP'S PERFORMANCE WHEN THE LATTER IS TAKEN AS 100[a]

	Young group	Middle-age group	Old group
Motor Learning			
Direct-Vision	100	98	84
Mirror-Vision	100	96	53
Verbal Learning			
Paired-Associates	100	92	83
Nonsense Learning	100	80	48
Interference Learning	100	72	46

[a] After F. L. Ruch, 1952, with permission of the author and the publisher.

In the context of the present discussion the physiological hypotheses of the Ruch investigation need not be evaluated. What Ruch had done was to select, with commendable astuteness, a series of tasks in the learning area which sorted out his ontogenetically classified groups. It is, perhaps, a testimonial to the orientation of psychological research in general that these exciting findings have stimulated neither intensive research efforts nor theoretical re-evaluations. Certainly, any system which pretends to be concerned with "general behavior theory" should have addressed itself to these intriguing outcomes. The older subjects have had more *experience* per se than have the younger, yet they manifest performance deficits when compared to their juniors. In the Ruch experiments, as in the Lashley and the McGinnis investigations, an attempt was made to vary the quality of the tasks which were presented to subjects differing in one instance in degree of experimentally induced brain damage, in the second case differing in intelligence test classification, and in the third set of studies differing in age. In each series when task and subject variables were manipulated together, results were obtained which suggest that factors not generally dealt with by extant learning systems play an important role in determining performance outcomes. The observations obtained in these investigations would seem to place a formidable burden on those psychological disciplines which are concerned with variations in performance which may possibly be attributed to organismic factors. It must be emphasized that organismic factors may derive from biochemical, physiological, or experiential variations. They may be attributable to variations in attentiveness, ability to store experiences, sensory acuities, motor endowments, genetically inspired attributes, or a host of other factors which function together to provide a manifold of determinants of behavior. Behavioral science ought to undertake manipulations designed to provide some insight into this complexity. It is the theme of this paper that developmentally oriented research may contribute significantly to this undertaking.

IV. The Recognition of Incomplete Pictures: A Series of Experiments within the Framework of Developmental Analysis

A. Introduction to the Problem

Werner (1948) and Piaget (1950, 1952) have contended that there is a developmental shift in judgment activity from dependence upon sensory-perceptual properties of tasks or stimuli toward reliance upon inferential or conceptual manipulations. Confirmatory evidence for the shift in cognitive operations has been reported by a number of investigators working in areas related to cognition; e.g., the development of social judgment (Gollin, 1958), the

development of equivalence transformations (Bruner and Olver, 1963), the development of styles of conceptualization (Kagan *et al.*, 1963), etc. These and other researchers indicate that developmentally early cognitive activity tends to be closely related to the sensory-perceptual characteristics of stimulus patterns, while later cognitive activity tends to include the use of conceptual materials, that is, information not directly present in the stimulus pattern (Gollin, 1960b).

Bruner has dealt with this behavioral dimension in a chapter entitled, "Going Beyond the Information Given," (1957) pointing out that all human use of evidence is likely to include characters that run beyond what is directly observed by the senses. He writes: "We propose that when one goes beyond the information given, one does so by virtue of being able to place the present in a more generic coding system . . . which provides additional information either on the basis of learned contingent probabilities or learned principles of relating material" (1957, p. 49).

Wohlwill deals with this issue by suggesting dimensions in which the progression from perception to conception may be ordered in quantitative terms. Relying in part on some of the data to be reported below, he has observed: "The age changes in the recognition of incomplete forms point to a . . . dimension of developmental change. Compared to the adult the young child requires more redundancy in a pattern to perceive it correctly; thus, incomplete . . . patterns will be difficult for him" (Wohlwill, 1960, p. 281).

A more elaborate discussion of redundancy and the other factors which relate perception to cognition has been presented elsewhere by Wohlwill (1962). For present purposes it is sufficient to note that redundancy plays an important role in recognition. Recognition occurs when an appropriate designating response is made by a subject to a stimulus with which he has had previous commerce. It differs from that type of generalization which reflects lack of differentiation, and resembles that type of generalization which arises in the course of discrimination learning; in human behavior the second type of generalization frequently involves components of active searching. Individuals not only recognize objects with which they have had no direct experience, but also those which are partially obscured, disguised, or altered with respect to their original representation. The experiments in the next section were designed to investigate the development of recognition behavior within the framework of the developmental redundancy dimension.

B. Specific Nature of the Problem and the Experimental Analysis

Initially it was necessary to devise experimentally useful tasks which would have applicability among widely disparate cross-sectional samples. The tasks

had to be within the response competency of very young subjects while at the same time they had to be difficult enough so that older subjects must do some work for mastery.

The main problem, once base data were obtained, was to explore, by experimental manipulation, both behavioral similarities and behavioral differences which were forthcoming.

Figure 2 contains examples of the materials used in all the experiments to be reported in this section.[3] In all but the first study (in which 11 series of pictures were used) there were 20 different common, meaningful objects, each represented by five degrees of completeness. *Set I* always refers to the most incomplete pictures, *Set V*, to the most complete pictures, while II, III, and IV have reference to degrees of incompleteness intermediate between I and V (See Fig. 2).

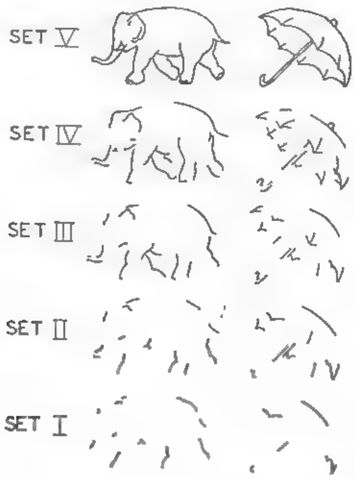

Fig. 2. Examples of the materials used in the experiments. (*After Gollin, 1960c, p. 290.*)

1. *The General Findings of the Exploratory Investigations*

Children in the age range 2½–5 years were presented with the pictures, one series at a time, starting with the *Set I* (most incomplete) representations and proceeding successively through Sets II, III, etc., until they responded with an appropriate verbal designator, i.e., a correct recognition response. A statistically significant negative relationship was found between CA and the degree of completeness required for recognition.

[3] The research reported in this section was supported by a series of grants from the National Science Foundation. Since the experiments have been published elsewhere, information on *S*s, procedure, methods, and results is presented here in general terms. Complete reports are to be found in Gollin, 1960a, 1961, 1962.

In a subsequent experiment, after a *pre-test* along the lines of the procedure already described, a group of children (about 3½ years) was given massed familiarization runs on half the Set V pictures and then given a *post-test* on all the Set I representations. Statistically significant improvement in recognition scores was found from *pre-test* to *post-test* for those pictures which had been used in the massed familiarization trials as well as for those which had not been exposed in that fashion. The improvement of scores on the latter pictures was not as great as on the former. A control group which had had no familiarization trials between the two tests also showed a statistically significant gain in recognition score from *pre-test* to *post-test;* however, this gain was significantly smaller than that of the experimental groups on "familiarized" pictures.

It appeared that minimal training, i.e., familiarization runs through the Set V cards, decreased redundancy requirements. Experience with the task itself also facilitated recognition even when no special familiarization procedure was employed.

The task appeared to have characteristics which would be useful for the proposed research: the materials differentiated among *S*s of differing ages; and even very young *S*s were able to improve their performance when they were given some training with the materials.

The training procedures were then altered to permit analysis of *subject* $\times$ *task* relationships. First it was established that *S*s of preschool age were able to recognize, on the average, only one out of the 20 Set I cards if they had had no prior commerce with the series. A comparably treated group of college students achieved a mean recognition score of 7.55 on the Set I cards.

Groups were set up so that MA, IQ, and CA factors could be included in the experimental designs. Training was conducted as follows: half of each group was given familiarization training on the Set III cards and then tested for recognition on the Set I cards; the other half of each group was trained on the Set V cards and then tested for recognition on the Set I cards. The two training Sets, III and V, may be considered to lie along a continuum with the Set I representations. Set V, on this continuum, would be more *distant* from the Set I test materials than Set III. The relationships between *generalization distance* and subject designators could, then, be explored. *S*s were given naming runs through the Set V or Set III cards. After an interval of one day *S*s were tested for recognition on the Set I cards which were presented in a different random order from that used in training.

Figure 3, modeled on Lashley's three-dimensional graph, is a slightly idealized representation of the over-all relationships which were found. Although CA is used in the graph as the subject category, the data suggest that the substitution of IQ or MA would, within limits, provide a similar set of interactions. It appears that when familiarization training is carried out with the Set

III pictures, which are close to the Set I cards in terms of *generalization distance,* there are no significant differences in mean recognition scores between age groups. However, when *generalization distance* is increased, that is, training is conducted with the Set V pictures, significant differences in mean recognition scores between age groups are found. The same general relationships appear to obtain, within limits, if MA or IQ is used as the subject designator.

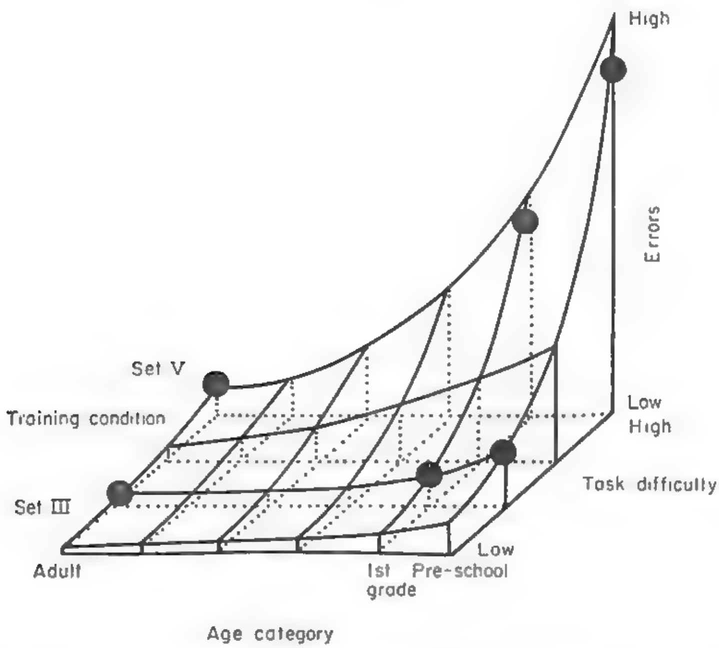

Fig. 3. A three-dimensional graph showing the relationship between age, task difficulty (generalization distance), and performance scores on the Set I recognition test.

2. *Age, Distance, and Delay*

The relationships presented in Fig. 3 provided an empirical base for further research. The new research was designed to introduce other relevant variables within the framework of the *subjects* $\times$ *tasks* design in order to obtain further information about the *Age-Distance* interactions which had been uncovered. Under the procedure previously employed, the recognition test (Set I) had been administered approximately 24 hours after familiarization training had been completed. It remained to be established whether the similarities of recognition performance among the age groups after Set III training, or the differences in recognition performance among the age groups after Set V training would be influenced if time between the termination of training and the onset of testing were manipulated.

College adults were assigned to eight different experimental groups. Half the groups were trained on Set III and half on Set V; one Set III group and one Set V group each were given the recognition test (Set I) 1 minute, 30 minutes, 60 minutes, and 24 hours after completion of training. The results of the experiment are presented in Table II. It will be observed that, in

TABLE II
TRIALS TO CRITERION AND NUMBER OF SET I PICTURES RECOGNIZED (ADULT *Ss*)[a]

Training condition	Time between training and test	N	Trials to criterion		Number recognized	
			M	*SD*	*M*	*SD*
III	1 min	15	2.52	.50	18.73	1.22
	30 min	15	2.60	.49	18.67	.82
	60 min	15	2.85	.61	18.20	1.21
	24 hr	13	2.86	.53	18.38	1.33
V	1 min	15	2.00	.00	17.33	1.35
	30 min	15	2.00	.00	14.20	2.65
	60 min	15	2.00	.00	15.00	1.96
	24 hr	13	2.00	.00	11.85	2.73

[a] After Gollin, 1961, p. 310.

general, as delay between training and test increases the recognition scores of the Set V groups decrease. The trend is statistically significant. On the other hand, the introduction of delay between training and test does not seem to affect the Set I recognition scores of the Set III trained groups.

Apparently, the relationship of *delay* and *distance* to recognition is interactive. How would developmental status (age) affect these relationships? To investigate the question an *Age* $\times$ *Training Condition* $\times$ *Delay* experiment was conducted. Forty first grade children (CA 6–7 years) served as subjects. They were divided equally among four experimental cells: Set III—1 minute; Set III—1 day; Set V—1 minute; Set V—1 day. Equal numbers of adult *Ss* were selected at random from the appropriate cells of the preceding experiment for comparison purposes.

The results of the experiment are shown in Fig. 4 and a statistical analysis of the results is presented in Table III. There are no statistically significant differences among Set III training groups. The age and delay factors apparently affect the recognition performance only of the Set V training groups. Thus, *age* and *delay* are interactive with *distance* but not with each other.

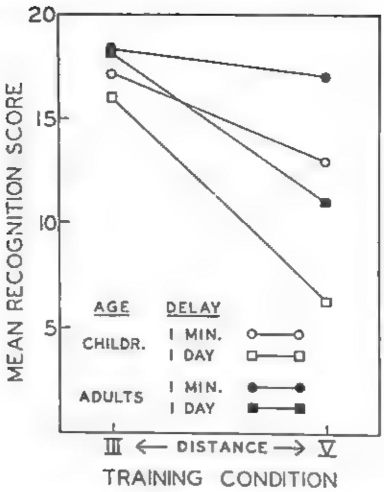

Fig. 4. Recognition score means of all groups on Set I. Each point represents an independent group. (After Gollin, 1961, p. 312.)

TABLE III
ANALYSIS OF VARIANCE OF RECOGNITION SCORES[a]

Source	df	MS	F	P
Age	1	183.01	41.12	<.001
Training	1	621.61	139.68	<.001
Delay	1	241.51	54.27	<.001
A × T	1	40.61	9.13	<.01
A × D	1	3.61	—	
T × D	1	165.31	37.15	<.001
A × T × D	1	.13		
Within groups	72	4.45		
	79			

[a] After Gollin, 1961, p. 312.

The *distance* variable, as it has been defined in the present discussion, appears to have developmental significance. When *Ss* *generalize* from III to I there are small and nonsignificant differences associated with age. However, when the *distance* between training stimuli and test stimuli is increased, V to I, there is relatively greater decrement in the recognition performance of the younger subjects.

3. *Age, Distance, Delay, and Degree of Training*

The training technique used in the work reported to this point has been a familiarization technique in which *Ss* were required only to name the training

stimuli. The technique was retained since it produced changes in recognition performance and data useful for developmental analysis.

It was recognized that training of a more intensive sort might alter some of the relationships which had been observed. For example, the previously employed training procedures led to a decrease in performance over time. Indications in the literature suggest that there should be an increment in the strength of generalized responses with the passage of time (e.g., Bindra & Cameron, 1953; Perkins & Weyant, 1958).

Another experimental probe was introduced in an attempt to increase the amount of effort required in training. The procedure was altered so that the

TABLE IV
MEAN NUMBER OF SET I CARDS RECOGNIZED

Training condition	Time between training and test	Group	Number recognized: Mean	SD
Set III	1 min	Children	17.55	1.94
	1 day	Children	18.99	.87
Set V	1 min	Children	5.78	2.05
	1 day	Children	10.56	2.65
Set III	1 min	Adult	17.55	1.51
	1 day	Adult	18.44	1.14
Set V	1 min	Adult	9.67	3.10
	1 day	Adult	11.11	1.76
Control		Children	6.20	1.88
		Adult	8.23	1.01

training sets were presented by the method of serial anticipation. Individual items were exposed for 3 seconds; inter-item time was 2 seconds; inter-trial time was 15 seconds. The training criterion was one errorless run through the "list" of 20 training pictures. The children who served as *S*s in this experiment were second and third graders (CA, $8\frac{1}{2}-9\frac{1}{2}$ years). The *distance* and *delay* variables were retained and altered training procedure was added.

Children required approximately twice as many trials to reach the training criterion as did the adults; the mean for children was 17.14; the adult mean was 8.83. There were no significant differences between the mean number of trials to criterion of the Set III and the Set V lists.

Table IV presents the mean number of Set I cards recognized by the experimental groups as well as the means of control groups who were given only the Set I recognition test. An analysis of variance of the scores of the experimental groups is presented in Table V.

There are no significant differences in recognition scores between the Set III groups of this experiment (high-work training) and those of the previous experiment (low-work training). There are no significant differences between recognition score means of Set III groups in the present experiment which are associated with age, or with time between training and test. When training stimuli closely resemble test stimuli, recognition scores are high, and recognition performance appears to be unaffected by degree of training, age, or delay between training and test. When the *generalization distance* is increased (Set V training), recognition performance is affected by the factors of age, delay, and degree of training. The relationships between these factors are shown

TABLE V
ANALYSIS OF VARIANCE OF RECOGNITION SCORES OF GROUPS TRAINED ON SET V AND ON SET III[a]

Source	df	MS	F	P
Distance (Di)	1	1422.21	360.97	<.001
Age (A)	1	16.04	4.07	<.05
Delay (D)	1	84.49	21.44	<.001
A × Di	1	29.39	7.46	<.01
Di × D	1	16.06	4.08	<.05
A × D	1	18.00	4.57	<.05
A × Di × D	1	8.03	2.04	
Within	64	3.94		
	71			

[a] After Gollin, 1962, p. 586.

in Fig. 5 where the Set I recognition score means of the Set V training groups of both the low-work and the high-work experiments are presented. Under high-work training conditions there is an increment in recognition scores with the passage of time. This contrasts with the decrement of recognition scores over time observed under low-work training conditions. Familiarization training (low-work) produces the highest recognition mean scores for both children and adults (1-minute delay groups); under this training condition the recognition scores of the two age groups decline at about the same rate over time. Under conditions of serial anticipation training (high-work) the rate of increment over time is greater for the children than for the adults.

There appear to be developmental factors associated with both the inhibitory effect which seems to be generated under the high-work training condition and its rate of dissipation over time. The different amounts of effort expended by the age groups in the training phase may be responsible for the apparent interaction between age and delay in the high-work training experiment.

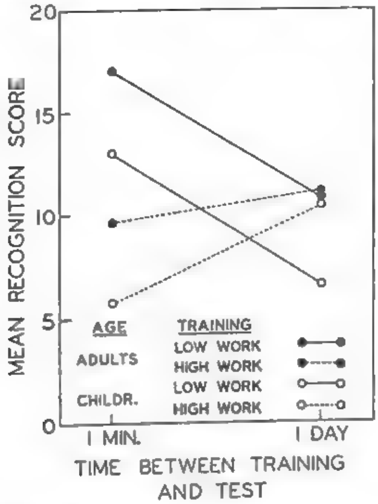

Fig. 5. Recognition score means obtained on Set I by groups trained on Set V under low-work and high-work training procedures. Each point represents an independent group of Ss. (*After Gollin, 1962, p. 588.*)

C. Summary and Discussion of the Recognition Research

The exploratory studies tend to confirm the notion that there are age related differences in the ability to recognize incomplete representations of familiar, meaningful objects. The cognitive operations of young children appear to be dependent upon the particular character of stimuli to a greater extent than are those of older children and adults. There is, apparently, a developmental progression from perceptual dependency upon stimulus properties to conceptual operations. The manipulation of the redundant character of stimulus patterns provides a means for investigating the nature of the developmental shift in cognitive activity.

A series of experimental probes indicated that preschool age children could, with moderate training, overcome redundancy requirements in the recognition of incomplete pictures. The introduction of the *distance* variable permitted the exploration of recognition behavior within the framework of generalization, and revealed age related differences in generalizing ability. These relationships, portrayed in the three-dimensional graph (Fig. 3), then became the object of further experimental probes within the framework of *age levels* $\times$ *task levels* designs. The introduction of delay between training and test did not affect the previously observed developmentally relevant interaction between *age* and *distance;* it acted to modify the performance scores of children and adults to about the same degree.

When more intensive training procedures were introduced, previously observed relationships between *delay* and *distance* were reversed, and an age related interaction with *delay* was observed. Intensive training depressed the recognition scores of children to a greater extent than those of adults when testing immediately followed training. Differences in recognition performance between the two age groups virtually disappeared when testing was conducted one day after training. The interaction between *age* and *delay* may be attributable to the greater effort (trials to criterion) expended by the children during training.

The program of research in recognition carried out within the context of a developmentally oriented approach has made it possible to observe similarities and differences in behavior of differing age groups. The subsequent investigation of these similarities and differences by means of experimental probes has sometimes resulted in the reduction of differences and the elimination of interactions between developmental status and stimulus manipulations, and sometimes led to increase of differences and more pronounced interactions. Both sets of circumstances serve the objective of increasing comprehension of the development of cognitive behavior. A variable which increases performance efficiency has obvious practical significance, and one that produces increasing performance differentials suggests directions for further research. Whether the variable is intentionally or fortuitously associated with some set of "explanatory" statements, its utility to the theorist should be considerably enhanced because of the context of its employment.

V. General Discussion and Summary

A. Relevance for Developmental Psychology

Developmental trends in learning and cognition can be discovered through the research procedures outlined in this paper. This strategy, pursued in a number of problem areas, should provide a powerful adjunct to longitudinal investigations in which the implication of the cross-sectionally derived information may be explored in individual subjects over long periods of time.

The strategy should also serve to focus experimental attention upon those periods in the course of development in which transitions in cognitive functioning are occurring. It should aid in the investigation of conditions which accelerate or retard shifts from "perceptual" to "conceptual" functioning, from "preverbal" to "verbal" mediation, etc.

The tactics of the research are concerned with the selection of appropriate cross-sectional samples, organismic categories, and task properties. There is no magic involved in making tactical decisions about the particular problem

under investigation. The decisions will be governed by knowledge already available in the general literature and by empirical excursions conducted during the pilot phases of research. Whether a recognition procedure such as has been described is employed, or a lever pressing technique is used, or any other specific of apparatus or method is exploited, will be determined by the problem under investigation.

Once the tactical decisions are made and base data are recovered, whether or not further experimental probes are undertaken, and whether one chooses to work with proximate or separated age groups, with bright or with dull subjects, will be determined by the interests of the investigator, the nature of the problem, and the empirical matrix which is being established.

It would be an abuse of the research strategy to use data obtained from widely separated age groups as the basis for formulating developmental principles. Wohlwill has pointed out (1960, p. 250): "It is patently not valid to extrapolate trends obtained from a few selected age groups to the whole course of development since age trends in this area are frequently discontinuous, nonlinear, and even U shaped." The developmentally oriented methodology proposed in this paper should be particularly useful in providing "trend" information and in checking tentative extrapolations.

B. Relevance for General Psychology

The developmental-experimental research strategy is neutral with regard to theory. Hypotheses tested within its framework will be afforded a more rigorous check than would generally be undertaken. If some hypothesis about the effects of reinforcement were to be tested within the framework of the design of Lashley's experiment, or the *subjects* $\times$ *tasks* design proposed for developmental research, the test would obviously be more representative than is usually the case. Some questions about the 'universality' of the system from which the hypothesis was derived might even arise. Certainly, any general statement about functional relations between stimulus events and response events that is examined in the proposed research context will have more scientific value than if the check were of a more restricted nature.

The approach is also neutral with respect to the issue of continuities and discontinuities in behavior, a problem which has been of concern to psychologists in many areas of psychology. A researcher working with the redundancy dimension, for example, might conceive of his problem in terms of levels. He might postulate the operation of a "perceptual " level or state and a "conceptual" level or state, and make predictions about S-R functional relations in those terms. Another investigator might prefer to regard the dimension as presenting a continuum and derive his predictions from that conception. These differences in working ideology might very well lead to the selection of different training

and test techniques, variations in task content, and the selection of different organismic categories for the experimental investigation. In any event, the discipline imposed by the successive experimental probes should present each "ideologist" with the opportunity to refine, modify, or abandon his theorizing.

C. Curiosity and Inquiry

In the course of espousing a very different research methodology, Sidman has discussed the role of curiosity in science (1960). He makes the interesting point that when an experiment is performed to test *no* hypothesis there can be no negative results. If the experiment is adequately executed, whatever results are observed are interesting. All psychologists are aware that *set* influences perception. Commitment to hypotheses is a form of "set" that is likely to exercise great influence upon observation and decision making during the conduct of research. The broader, less confining attitudes accompanying curiosity-inspired research may convert "errors," "inadequate" subjects, and "faulty" apparatus into promising leads for new directions of research.

There is room for theoretical models, pretheoretical models, and amorphous models in the formulations of psychologists. The utility of one or the other approach will be decided on the basis of empirical checks. The research format that has been described in this chapter should prove highly useful, not only for testing hypotheses, but also for probing patterns of observed relationships and opening new directions of inquiry.

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EVIDENCE FOR A HIERARCHICAL ARRANGEMENT OF LEARNING PROCESSES[1]

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I. Introduction

This paper will review several lines of research on children's learning, and certain other areas, which appear to have come close enough together to make it worthwhile to suggest theoretical linkages among them. While much research is needed to fill in, elaborate, and undoubtedly correct, almost any point of the discussion, it is hoped that such a review will have value in throwing open for discussion a plausible theoretical skeleton, and in suggesting areas where further research and conceptual clarification might be useful.

The central concern is with interpretation of changes in the character of children's learning which are known to take place as children reach the age range from 5 to 7. A strong case, resting on widespread evidence and on a series of previous theoretical assertions, may be made for regarding this age period as a time of unusually significant change. An ideal statement of what that change is—a statement of how it is to be understood in terms of process—should account for all these discrete supporting sources. The present paper will, unhappily, fall short of such an ideal and complete interpretation of the variety of documented or speculated transitions. The developmental literature is rich enough to suggest complexity, but is frustratingly sparse and elusive when exact mechanisms are to be drawn up.

It would seem a useful step forward to attempt to focus the problem of interpretation: (*a*) to review the numerous behavioral changes in the 5–7-age period and thereby suggest the scope of the transition; (*b*) to examine a current interpretation of some of the research material—the suggestion that the transition consists essentially in a new mediational use of language; and (*c*) to present for consideration a more general formulation within which the mediational hypothesis might be encompassed.

II. A Model Structure: "Temporal Stacking" in Learning Paradigms

Given that the general goals of the review have been stated, it will be convenient to begin our consideration of data somewhat far afield. The interpretation of the 5–7 transition to be offered later will lean heavily upon a mechanism of inhibition which is presumed to have its first sizable influence on behavior during this age range. In picturing this inhibitory mechanism, it will be useful to have at hand a model structure, a structure which appears to fit a set of experimental cases where the influence of inhibition upon behavior is more or less clear. This appears to be true in certain learning paradigms. In fact, it was from a consideration of learning, and the influence of response restraint or inhibition upon learning processes, that the more wide-reaching hypothesis was first conceived.

Evidence indicates that competing responses in several kinds of learning are "temporally stacked," that is, that different responses become maximally "ready" in different time zones after the stimulus has initiated the hunt for a response. Thus, any momentary or long-term influence which tends to speed up or slow down a subject's response tempo will to some extent also determine his selection of the responses available to him. Consistent selection of long-latency responses would appear to depend critically upon the subject's ability to inhibit or delay delivery of a response.

A. Covert Competition in Associative Transfer

One of the clearest cases of response competition in learning studies occurs in the paradigm for associative interference, usually schematized as an A-B,A-C arrangement. Given a stimulus "A", the subject first learns the response "B" and then, in second learning, must instead learn to give response "C."

Spiker and Holton (1958) analyzed error patterns found in A-B,A-C transfer in a series of studies. Their analyses showed evidence of a peculiarly covert struggle between first learning and second learning. Unlike animals, who persist in a learned response for some time after it turns inappropriate, human subjects begin withholding their first-learned response almost as soon as one or two error signals have indicated that something has gone wrong, something has changed. Though the first-learned response is suppressed, there are signs that it competes with the second-learned response.

If subjects had to respond within 2 seconds of stimulus onset, associative interference manifested itself in omissions of response within that time limit; the more the first training on an A-B response, the more the errors of omission

when an A-C response was called for subsequently. If a more lenient time limit was given the subjects (up to 4 seconds to make a response) then there was no evidence of associative interference either in errors of commission or of omission (White *et al.*, 1960). Under these circumstances, competition was reflected only in the speed with which a subject delivered his correct A-C response (Fig. 1).

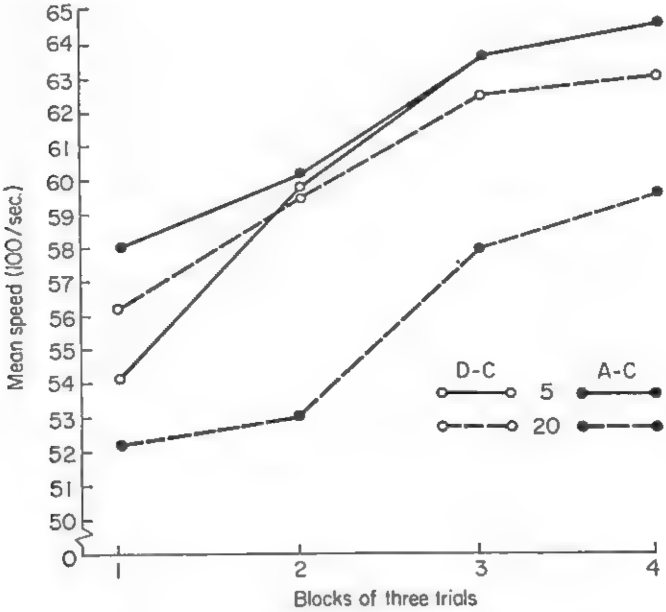

Fig. 1. Associative interference manifested in response latency. Subjects were given either 5 or 20 trials of A-B training, then transferred to D-C (control) or A-C (associative interference) learning conditions. After 20 trials of training, A-B, A-C interference was manifested in significantly longer response latencies during second learning. (*From White et al., 1960*).

A partly hidden sequence could be inferred from such a pattern of findings—the A-B response arising first and being restrained, the A-C response arising second. If the ultimate effect of the first learning was to force the subject to hesitate before responding, then one would assume that the pause represented the upwelling of the old learning. There are several indications that this is correct. Analyses by White *et al.* (1960) of the data of generally fast, medium, and slow responders showed that the fast subjects tended to make more associative interference errors even given a long time to respond—as though such subjects, by their speed, forced out first-learned responses latent under the pause period. Siipola (1940), who studied A-B,A-C transfer with a special motor procedure which allowed incipient movements to be recorded,

showed that subjects in the transfer portion of an A-B,A-C sequence are apt to make slight A-B movements of a response lever, checking those movements, before delivering a correct A-C response.

It is of considerable interest that human subjects are able to restrain interfering responses, but that they are apparently not able to disregard them. This clearly suggests that there is a fixed time order in which responses become available to the subject. It is this immutability of order which makes it possible to augment associative interference by procedures which force fast responding. Castaneda and Lipsitt (1959) have provided some indication that forced fast responding augments associative interference. In other work, Castaneda and his associates have shown that anxiety also augments associative interference (Castaneda *et al*, 1956; Palermo *et al*., 1956). Is it possible that anxiety augments conditioning and increases associative interference primarily by serving as a disinhibitor of first-available responses?

B. Temporal Stacking and Stimulus Generalization

We turn once again to our quest for data delineating a model structure of competition. Usually, stimulus generalization procedures do not involve response competition. The subject is given extensive practice at responding to a training stimulus and is then presented with test stimuli to which he may respond or not. Typically, the subject begins a sequence of generalization test trials by delivering false responses to the stimuli similar to the training stimulus. After a time, such responses drop out while response continues to presentations of the training stimulus; generalized responses are said to extinguish faster than conditioned responses. Such cessation of generalized responding must be linked with the capacity of the subject to inhibit responding, and thus Thompson (1962) has reported that removal of cortical material in cats leads to enhanced generalization, apparently by reducing the ability of the animals to form response inhibition. Similarly, human adults who are high in spontaneous GSR activity, a characteristic associated with impulsiveness, show heightened amounts of stimulus generalization (Lacey & Lacey, 1958; White & Grim, 1962).

A rather clear picture of the kind of temporal stacking mechanism under discussion occurs in a two-response form of the stimulus generalization procedure, where the subjects are asked to make one response to the training stimulus and another response to any other stimulus which may be presented. Such a procedure, yielding amounts of generalization equivalent to the more usual form of the generalization experiment (Brown *et al*., 1951), is uniquely advantageous in that it allows the experimenter to time both generalized and nongeneralized responses to the test stimuli. When such timing is done, gen-

eralized and nongeneralized responses are seen to occupy different time zones after the stimulus onset (White, 1965a); Fig. 2 shows this.

Figure 2 was constructed from 1200 test-trial responses, 12 trials from each of 100 subjects, and the schematization in the figure is a blend of within-subject and between-subject factors. Faster subjects gave more generalized responses than slower subjects. The responses delivered by any given subject were faster when they were generalized than when they were not.

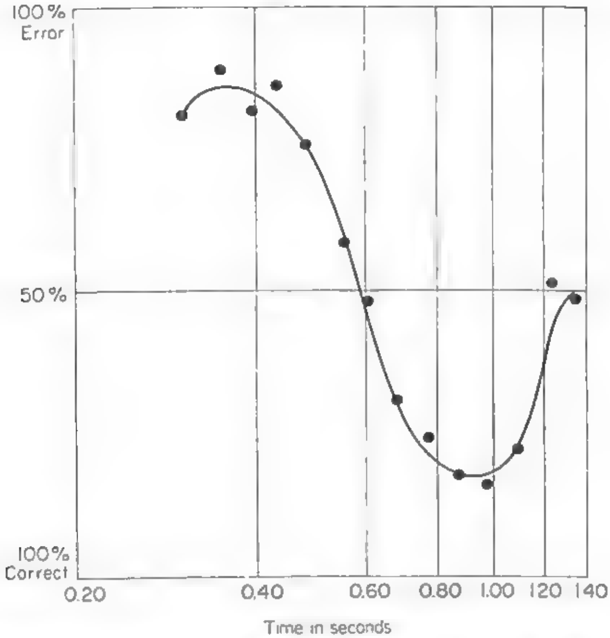

Fig. 2. Temporal stacking of responses in a generalization procedure. The curve pictures correctness of response as a function of time taken to respond during test trials of a generalization procedure (White, 1965a).

Note, also in Fig. 2, that the effect of short-latency responding is to produce 80% errors. We are not dealing here simply with random response brought about by overhastiness; in that case, one would expect 50% errors toward the left of the figure. The consequences of quick response are, apparently, systematic, and this is indication that the alternative responses exist each in their own time zone.

Competing responses have been conventionally schematized as a vertically arrayed habit-family hierarchy, a set of responses all attached to the stimulus and stacked in order of their probabilities of occurrence. The similarities and differences between this schematization and the temporal stacking notion may best be imagined if this picture is rearranged to form a horizontal hierarchy, with responses ordered along a time line. Such a conception may be of use

in explanation of a variety of observed generalization phenomena (White, 1965a).

C. Influence of Response Timing on Discrimination Learning

A third kind of response competition is found in a kind of discrimination learning where, faced with a pair of stimuli, the subject may make either of two responses. Some recent unpublished analyses of such discrimination learning have revealed evidences of a temporal arrangement of responses similar to that which has been pictured above in generalization data. The data are pictured in Fig. 3.

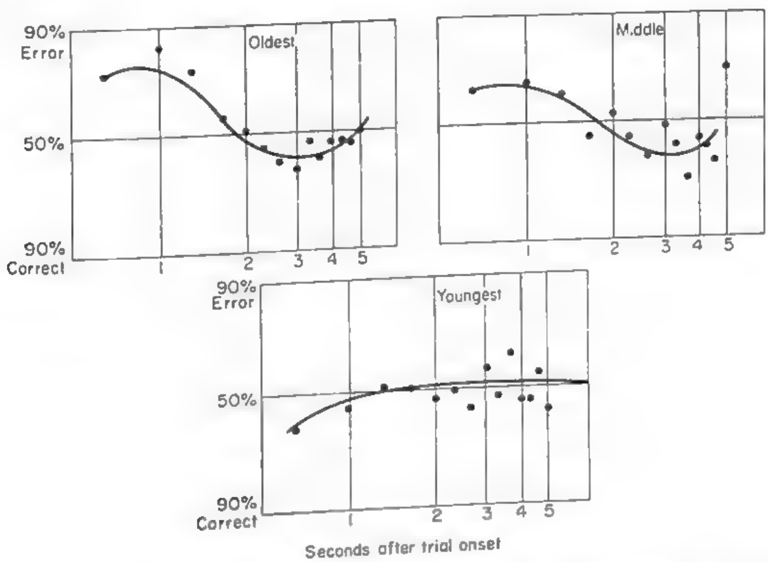

Fig. 3. Temporal stacking of responses in a discrimination procedure. These curves were drawn from data of a two-choice simultaneous discrimination procedure, and picture correctness of response as a function of time taken to respond. The terms "youngest," "middle," and "oldest" refer to school groups and mean, roughly, age ranges of $3\frac{1}{2}$–$4\frac{1}{2}$, $4\frac{1}{2}$–$5\frac{1}{2}$, and $5\frac{1}{2}$–$6\frac{1}{2}$ (unpublished data).

It will be noted that the temporal organization of the responses is not nearly so marked here as in the generalization data. The data for the youngest group of children pictured in the figure do not show the responses arranged in time zones at all. Quite possibly, the lack of temporal zoning in these data are related to a special factor which enters into discrimination learning—the position-guided error factors. There is good reason to believe that children often are not in conflict between positive cue and negative cue when they are in the process of discrimination learning; rather their responses seem

to be based on strategies involving the positional loci at which the cues appear. Responses determined by position would presumably have a different timing logic; they would be noisy elements in the pictured figure.

These data, it is realized, raise questions about discrimination learning which cannot be explored in the context of the present review. For the moment, we are interested in them only as another instance of what we here term a "model structure."

D. The Model Structure

In all three paradigms, associative interference, stimulus generalization, and discrimination learning, competing responses are found to be arranged in zones along a time line and timing becomes a factor in choosing among them. Impulsive behavior leads to first-available responses, while restraint is necessary to the production of second-available responses.

The three kinds of experimental procedures under discussion all happened to involve competition between only two responses, and it is possible to conceive of two kinds of temporal stacking mechanism which would fit them. In the first, the two-choice case would be the minimal case of *n*-stacking. One could imagine a series of *n* responses strung along a time so that each response has its own modal locus. Such a conception has a logic to it; it flows from the often-demonstrated fact that response speed increases with training. Imagine, for a moment, a series of five alternative responses to a stimulus, ideally equiprobable or, in our terms, all ideally located at the same point on the time line. Imagine that we give these five responses different amounts of reinforcement, R_1 the most and R_5 the least. One would expect these five responses now to be delivered at different speeds, R_1 most rapidly and R_5 most slowly. The present conception substitutes the word "available" for the word "delivered" in the previous sentence with the following implication: If one could control where along the time line the subject's response would be delivered, one could to that extent also control which of the five responses would be selected.

There is another possible interpretation of the temporal stacking mechanism, however, which is that in essence there are only two zones—a zone of automation and a zone of decision. If, through prolonged training, a response is drilled in to a particular cue, it is possible that such a response becomes established in an automation system which has privileged, short-latency, access to response selection. If the subject senses novelty and/or an unpleasant event, he inhibits the automated system and switches to the decision system for determination of response. Here one response is first-available but, if this response is inhibited, selection of another response is decided not by temporal priorities among the remaining response alternatives but by reflective operations which can bring

forth any of the alternatives as second-available in time. This, too, echoes an older conception, an introspectionist one, the oft-repeated dictum that "Consciousness occurs at the moment of conflict."

Compromises between "*n*-stacking" and "two zone" hypotheses are conceivable, for example, the notion of a zone of automation containing several responses with different characteristic latencies, and a zone of decision out further on the time line. Selection among all these alternatives could perhaps be made through experiments where three or more competing responses are timed.

It is, of course, a commonplace that speed is opposed to accuracy in behavior. Why make a formalistic case about it? For one thing, the analyses of short-latency responding have indicated that quick responses do not represent random selection among the alternatives available to the subject, but instead are biased—and the bias requires explaining. For another, the interesting thing, really, about a too-quick response is not its inaccuracy but its near-accuracy. If we consider that an overhasty response is usually a reasonable selection from among thousands of wildly irrelevant responses a subject might launch into at any instant, if we consider that it is usually almost as appropriate to the situation as a well-thought-out response, we must conclude that some quite excellent cognitive system must be involved in the selection of a hasty response. "Unthinking," "heedless," "hair-trigger," "careless," "bird-brained," "hare-brained" reactions have a logic, too.

III. Behavior Changes in The 5–7 Age Range

Having discussed evidence for a model structure we will, for a time, lay that structure aside and take a very different tack.

Within the recent research literature on children's learning, two pronounced age changes in learning have received considerable attention. Kuenne's (1946) demonstration of a shift from narrow to broad transposition has been an important influence upon the literature of experimentation on children's learning. In recent years, the studies of post-discrimination reversal and nonreversal shifts by the Kendlers (Kendler & Kendler, 1962a; Kendler, 1963) have corroborated the most general interpretation of the transposition findings in rather basic respects. Both lines of research appear to argue together that:

1. A fairly basic and important change in the character of learning appears to take place after age 5.

2. Before this age, the pattern of findings obtained with children resembles those obtained when animals are used in like procedures. After this age, the pattern of findings approximates that found for human adults. The transition is from animal-like to human-like learning.

3. This transition is associated with an increased apparent influence of language upon learning.

A characteristic strategy in experimental work with children has been to use children in experimental procedures like those used with animals, to assimilate the data of children to theories based upon animal work where comparable results are obtained, and to write fresh theory where children depart from the kinds of behavior which animals show. In terms of such a strategy, the Kuenne and the Kendler demonstrations stand out as events of first importance, because here, apparently, there is a twice-confirmed age where human performance breaks away from animal performance.

There are many who quarrel with such a strategy, but it must be said that these studies have located, and labeled significant, the age period from 5 to 7 which many other theorists, using other strategies, have found important. This is an extremely interesting convergence in a developmental literature not given to major convergences. In order to analyze these learning shifts fully, it would seem worthwhile to examine all the converging experimental literature and all the converging hypotheses of change. Perhaps a broader and firmer base can thereby be constructed for an understanding of the learning material.

The present section will review the additional evidences of change. By and large, each evidential item is weak and many obviously require the simplest kinds of replication and exploration studies. Even where there has been extensive follow-up work, as is the case for transposition, many issues are unsettled. It seems best, because of this, simply to number and narrate the various transitions, adding a few interpretative comments where there seems to be something to say but leaving ultimate interpretations to the follow-up studies which are not yet here.

A. Changes in Learning

By far the largest number of transitions reported have been changes in various kinds of learning performances—perhaps because it is learning which is principally affected at this time, perhaps because so much research concentrates on learning. The first two transitions have already been mentioned briefly.

1. *Narrow to Broad Transposition*

The classic demonstration of transition (Kuenne, 1946) involves a broadening of transposition. The younger child, having learned to choose the larger of two stimuli, will now choose the larger stimulus on a near test but not on a far test. The older child will choose the larger stimulus on both a near

test and a far test. There has been extensive follow-up of this finding, some of it reviewed in Reese (1962) and White (1963); these follow-ups have not yet settled whether verbalization is a cause or a correlate of the behavioral transition, but that there is such a transition is little disputed.

2. *Easier Nonreversal Shifts to Easier Reversal Shifts*

The transition described in a series of papers by the Kendlers (cf. Kendler & Kendler, 1962a; Kendler, (1963) is more complex. Table I schematizes the experimental arrangements which define what are called reversal and non-reversal shifts. Younger children do better when transferred to the arrangement which calls for a nonreversal shift; older children do better when dealing with a reversal shift.

Table I also schematizes a variant procedure where the comparison is not between separate groups of children given reversal and nonreversal conditions

TABLE I

OUTLINES OF TYPICAL REVERSAL-NONREVERSAL SHIFT ARRANGEMENTS[a]

1. Reversal-nonreversal shift design		
Stage 1		Stage 2
Training		*Reversal shift*
		lb(−) vs. sb(+)
lb(+) vs. sw(−)		lw(−) vs. sw(+)
lw(+) vs. sb(−)		*Nonreversal shift*
		lb(+) vs. lw(−)
		sb(+) vs. sw(−)
2. Variant procedure		
Stage 1	Stage 2	Stage 3
Training	*Optional shift*	*Test*
lb(+) vs. sw(−)	lb(−) vs. sw(+)	lb(−) vs. sw(+)
lw(−) vs. sb(+)		lw(+)[b] vs. sb(+)[c]

[a] l = large; s = small; b = black; w = white.
[b] Consistent choice scored as reversal-shift.
[c] Consistent choice scored as nonreversal-shift. Choice divided between *b* and *c* scored as inconsistent shift.

but where, instead, each child can elect to make a reversal, nonreversal, or inconsistent shift (Kendler *et al.*, 1962). When children of different ages were compared on the variant procedure, reversal shifts were found to be preferred to nonreversal shifts at all ages from 3 to 10. Preference for reversal shifts increased steadily with age, but this was at the expense of inconsistent shifts, which showed a parallel decline. The percent of children choosing nonreversal shifts remained steady with age. The results found using both the original and variant procedures can be interpreted as supporting the

Kendlers' contention that development implies greater mediational control over behavior, but the two lines of evidence are not perfectly consistent. Why, given the results of the variant experiment, do young children ever do better at nonreversal than at reversal shifts?

3. *Onset of Resistance to Classical Conditioning*

Some time ago, Razran (1933), reviewing research on conditioning experiments with children, reported that the susceptibility of children to conditioning increased until about age 6, declining thereafter apparently because of an increasing resistance to conditioning, an unwillingness to submit to it. There has been a general dearth of studies of classical conditioning in children, and this interesting report has not been followed up. Certainly, there is evidence that adults can inhibit CR's, to some extent, if they choose—and perhaps the ability to do so begins at 6. However, it is also possible that the transition represents the beginning of a decline in emotionality at this time. Braun and Geiselhart (1959) report a steady decline in susceptibility to conditioning from ages 9 to 70, with essentially no conditioning at all in their oldest group. It seems implausible that a motive to resist conditioning should increase steadily with age.

4. *Change in Effect of a "Varying-Position" Condition*

Children were asked to solve a two-choice simultaneous discrimination problem in which the two stimuli were presented in a triangular array of three windows. In the control condition, the choices were presented in the two windows at the base of the triangle, and the child faced his choices in the left-right, right-left settings common in the presentation of such problems. Under the Varying-Position condition, any two of the three windows were used to display the stimuli, and successive trials alternated six possible settings. The positional variation had a marked effect upon the discrimination learning of the children, the effect depending upon age. It hindered the younger children and helped the older (Fig. 4) (White, 1965b).

5. *Difficult to Neutral "Varying-Positive" Condition*

A series of discrimination studies compared Control, Varying-Positive, and Varying-Negative conditions in children of differing ages. The Control condition was a standard two-choice simultaneous discrimination problem, with one stimulus positive and the other negative. In the Varying-Positive condition a set of 20 stimuli took turns as positive cue from trial to trial, while the negative cue was constant over all trials. The Varying-Negative condition used any one of a set of 20 stimuli as negative. Comparisons of these conditions at

a series of grade levels (Fig. 5) indicated a shift of the Varying-Positive condition from a deleterious to an apparently neutral condition at the kindergarten age level, and a relatively slower shift of the Varying-Negative condition from deleterious to neutral (White, 1965b). The results for the youngest children are like those obtained by House *et al.* (1957), who compared Varying-Positive, Varying-Negative, and Control conditions using retardates. The results for these retardates, of an MA level comparable to the CA level of the

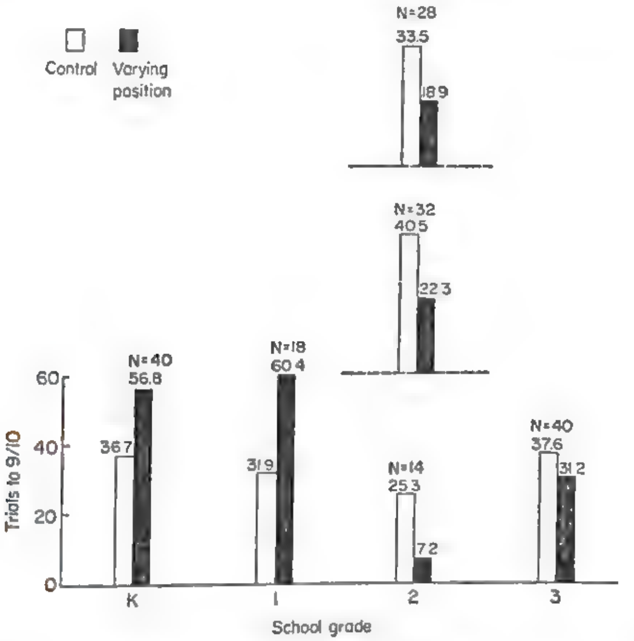

Fig. 4. Results of six comparisons of Control and Varying-Position conditions at four different grade levels. All children learned a two-choice simultaneous discrimination problem. Under the Control condition, the problem was presented with discriminanda in the usual side-by-side spatial arrangement. Under the Varying-Position condition, the sites of choice varied from trial to trial (White, 1965b).

youngest group, are indicated by the free-standing points at the left of the figure.

The free-standing points at the right of Fig. 5 were obtained from fourth graders, by the imposition of a kind of handling which might be interpreted as stressful (White, 1965b). They resemble the youngest pattern. Such data are of considerable interest bacause they suggest that the age progression pictured in the figure is not irreversible, that some ways of handling children may induce regression.

But the general age trend itself, taken together with the data pictured in Fig. 4, suggests that, normally, young children find extraneous cue variation

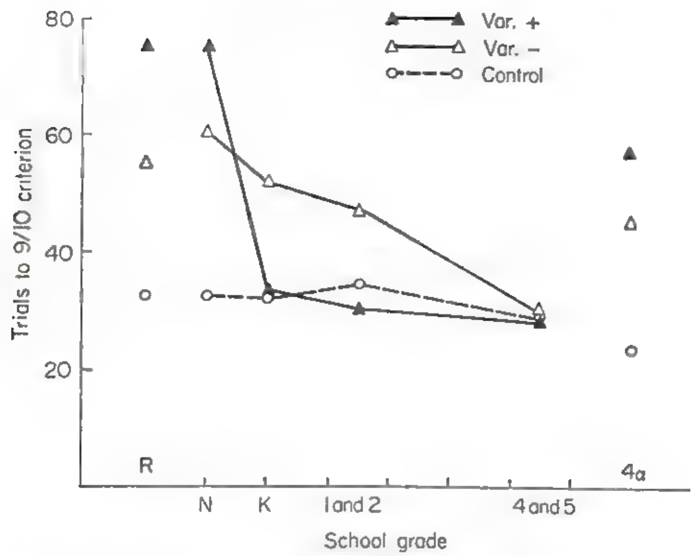

Fig. 5. Results of comparisons at differing ages of Control, Varying-Positive, and Varying-Negative discrimination learning conditions (White, 1965b). For explanation, see text.

an interfering factor in learning (cf. Gollin, 1960, 1961), and that between 5 and 7 at least some kinds of extraneous variation become neutral, or even beneficial, conditions for learning.

6. *Growth of Inference*

Kendler and Kendler (1926b) compared kindergarten and third grade children on an inference task in which the subjects first learned the three discrete sequences A-B, X-Y, and B-G, and then were given A and X and told to get G. That is, they learned that one button (A) yielded a marble (B); another (X) delivered a ball bearing (Y); and only the marble (B) yielded a toy trinket (G). When told to get the trinket, the subject's most direct route was the sequence A-B, B-G. He could also obtain G by an indirect route, interpolating other responses. Fifty percent of the younger children were able to obtain G, 6% by a direct route and 44% by an indirect route. Eighty-eight percent of the older children obtained G, 50% by a direct route and 38% by an indirect route. There was, then, a marked increase in the ability to make a direct-route inference between the two ages.

7. *Possible Interference of Complex Hypotheses*

There is some evidence that efficiency in simple discrimination learning may decline somewhat as children get older. Evidence of Stevenson *et al.* (1955),

Weir and Stevenson (1959), and Kendler and Kendler (1962b) suggests that there is improvement in discrimination learning up to the 5–7-age range but, at least with simple problems, a decline thereafter. Why this is so is not clear, but it is plausible that older children adopt complex hypotheses which actually interfere with their performance on simple problems. A decline in discrimination performance after age 7 would imply that there is some augmentation of the ability to adopt complex hypotheses at about this age—an implication which finds some support in the studies of children's probability learning in this age range (White, 1963).

B. Perceptual Changes

The literature on perception in childhood is scant. Even given that scantiness, however, evidence has appeared suggesting two transitions in children's perception during the 5–7 period.

8. *Shift from Tactual to Visual Exploration*

There has been considerable speculation that children progress from tactual, kinesthetic, proprioceptive, and visceral sensitivity to progressively greater concern with visual and auditory cues, a shift from "near receptors" to "distance receptors." Thus, Bruner (1964) has suggested that the earliest representation one finds in children is enactive—in motor patterns—and only later are environmental inputs stored in visual imagery, and finally in coded representation. Birch and Lefford (1963) have shown that children only gradually come to integrate haptic and kinesthetic percepts with visual percepts as they grow older.

A brief report is available of a study by Boguslavskaya (Zaporozhets, 1961) in which children were faced with an array of stimulus objects and ratings were made to determine whether their exploration of these objects was predominantly tactual or visual. A majority of the exploration was rated as tactual at age 3–4, while at age 6–7 a majority was rated as visual.

Data confirming such a trend appeared in research by Schopler (1964). Children were presented with four pairs of play situations; in each pair, one choice offered relatively more tactual stimulation, the other relatively more visual stimulation. During successive fixed intervals of time the child could (*a*) hold down a lever which caused a slide projector to present a slowly changing series of pictures, or depress a lever mounted on a vibrator; (*b*) view a rotating display of toys, or manipulate the same toys within a dark box; (c) play with a kaleidoscope, or play with putty; (d) play with many-colored blocks, or play with neutral-color blocks covered with fur, sandpaper, glass studs, etc. The last pair failed. The "tactual" blocks were visually unusual,

and older children showed an ever-increasing interest in them. But, over-all, there was still a progressive increase from age 3 to age 9 in proportion of total time spent playing with the visual choices. Absolute time on the tactual materials stayed constant with age, while absolute time on the visual materials showed a progressive increase.

Again, in this line, there are some data suggesting either regression or lack of development with pathology. Schopler found that schizophrenic children were significantly less visual in preference than controls of the same CA, though a sample of retardates were "at their age." Hermelin and O'Connor (1961), however, have reported that imbeciles were superior to normal children in tactual recognition, though poorer in visual recognition of figures.

9. *Shift to Form-Dominance*

For stimuli presenting themselves in the visual modality, children shift from relative "color-dominance" to "form-dominance," the transition occurring around age 6. The most common experiment is one in which children are faced with a set of three colored patterns, a standard and two choice patterns, one choice like the standard in form but not in color, the other choice like the standard in color but not form. The children are asked to select which choice pattern is most like the standard. Children after 6 will choose on the basis of form most of the time. The situation is less clear before 6. Some work suggests that children are predominantly color-dominant immediately before 6 (Brian & Goodenough, 1929; Colby & Robertson, 1942); other work suggests that they show mixed dominance before 6 (Descoudres, 1914).

House and Zeaman (1963), working in a very different setting, have produced data consonant with the general trend of the findings. They used retarded children with MAs ranging from 3 to 8 years in a learning procedure. Color or form cue choices were possible during "conflict trials" following reinforcement of both color and form cues. Their data reveal a 50-50 choice of form and color in the 3–5-MA range, increasing to about 60% choice of form cues in the older MA ranges.

There is some evidence to suggest that the color-form shift may be affected by pathological processes. Deaf children are found to be color-dominant from 8 to 12 years of age, when a majority of normal controls are form-dominant (Doehring, 1960; Gaines, 1963). Eysenck (1947) has suggested that adult color-dominance is associated with neuroticism. Rorschach scoring, as is well known, interprets excessive response based on color as a sign of lack of emotional control and immaturity, while response to form elements indicates control and structure.

It has been suggested that the move toward form-dominance may be associated

with the representation of visual percepts in words, which emphasize the form aspects of visual cues (Carroll & Casagrande, 1958; Kagan & Lemkin, 1961).

C. Transitions in Orientation and Localization

10. *Development of Personal Left-Right*

Children become able to tell their left from their right at about age 6. The distinction is made from their own point of view and only later do they become able to clearly tell objective left from objective right—for example, the right and left of someone facing them. Piaget (1959) cites his own work, age-placement on the Binet-Simon test, and other work to this point. Benton (1959) has argued that the sense of leftness and rightness must be closely tied to verbal symbolic processes, noting, for example, that right-left disorientation is so frequently associated with aphasias that Head considered such disorientation a diagnostic sign of aphasia. The acquisition of a sense of right-left may, somehow, be tied to language development at age 6.

11. *Decrease in Form, Word, and Letter Reversals*

Marked improvement has been reported during the 5–7-age period in children's ability to discriminate reversals of perceived figures. Davidson (1934) gave children between 4 and 9 a "Form Perception Test" and a "Word Perception Test." The Form Perception Test presented a key form and five choice forms, one of the choices identical with the key form and another of the choices a reversal of the key form. The child was to circle the choice form which was the same as the key form. The Word Perception Test was similar, presenting a key word and choice words. She reported: "The average number of both form and word reversal errors appears to decrease distinctly at the mental age of 5½ years and the word reversal errors again decrease distinctly at the mental age of 6½ years, but not so the form reversal errors."

The reversed words presented in the Word Perception Test were not mirror images of the key words, but instead were the key words spelled backwards. It is difficult to see how this kind of a word reversal would be chosen through confusion in perceived orientation of the word as a printed figure. In addition, the younger children in this study were not at the usual reading age. One might wonder how much these findings were based on a tendency of the younger children to make random choices among their alternatives.

In another study, Davidson (1935) gave a "Letter Perception Test" to children between 5 and 8. A sample letter was given, and the subjects had to cancel all instances of the sample in four rows of letters. A marked decline in letter confusions is reported between the mental ages of 5 and 6 years,

and another at 7½ years. Davidson suggests that children may overcome upside-down confusions (*e.g.*, n-u, b-p) at a younger age, and left-right confusions (*e.g.*, d-b, p-q) at a later age.

12. *Ability to Hold Spatial Information through Disorientation*

An experiment by Emerson (1931) involved a situation in which an experimenter hung a ring on one peg in a vertical matrix of pegs, removed the ring, and asked the child to repeat his placement. Even very young children were able to replace the ring correctly on the board if they maintained continuous orientation facing the board. If the children had to repeat the placement on a set of pegs back-to-back with the model set, the 180° rotation confused the younger children but not the older. Werner (1961) briefly reports a replication of the Emerson experiment with children aged 6 to 10, and suggests that older children hold their information through disorientation by encoding the ring location in conceptual-verbal terms. The age of transition is not given by Werner. However, unpublished data of Drake (1964) suggest that the transition occurs in the age range under consideration here. She used the Emerson procedure with four groups of children aged 3, 4, 5½, and 7½. A part of her data is given in Table II. It is evident that all children in her study

TABLE II
PERCENT CORRECT REPLACEMENT OF A RING ON A 6 × 7 FIELD OF PEGS (DRAKE, 1964)

Condition	Age			
	3	4	5½	7½
Unbroken fixation on model board	95	88	100	100
Turns back to board for several seconds	36	48	58	78
Uses new board back-to-back with model	7	10	14	52

were able to perform adequately if unbroken visual and bodily orientation was maintained with respect to the pegboard. If such orientation was once broken and then restored, serious decrement in performance occurred in the very youngest children, but a relatively minor decrement in the older children. If the orientation was permanently altered, then only the very oldest group of children showed a reasonably good level of performance. This growing ability to hold information irrespective of orientation might be related to the general decline in position-guided behavior during discrimination learning which is frequently noted in this age range (cf. House & Zeaman, 1963).

13. *Change in the Face-Hand Test*
Another reported change during this period has to do with a change in dominance of distal by proximal stimuli. Children under 6 do not indicate awareness of a touch on the elbow, wrist, or hand if the face is touched simultaneously; they report only the touch on the face. There is a marked change at six towards an ability to report both (Cohn, 1951; Fink & Bender, 1953).

D. Change in General Intellective Measures

Discussing the problem of predicting adult IQ, Goodenough (1954) has said: "No study that has yet appeared has shown more than a moderate relationship between the results of tests given before the age of 6 and those administered in later childhood or at maturity." It appears that maximal prediction begins to be possible at six, though some correlation is found before then.

14. *Increasing Predictability of Adult IQ*
Longitudinal studies of IQ measures have shown that the correlation of such measures between ages 2 and 18 is about .30. This minimal correlation rises over the next few years until, at about ages 5–7, the correlation with later IQ reaches a maximum in the .70's (Bayley, 1949, 1955).

Similarly, Bayley's correlations of midparent education and child's IQ, and Honzik's correlations of mother's education with the IQ of her child reared apart, all become maximal in the age range from 4 to 6. (Cf. Jones, 1954, Figs. 6 and 14.) Such correlations could mean that a maximum communality between the intellective functions of children and adults is reached after 7, or they could reflect shortcomings in test design. One could, perhaps, argue that types of items not yet tried in the preschool range might predict adult IQ better.

15. *Emergence of "Factor III"*
Hofstaetter (1954) has factor analyzed the longitudinal intelligence test data provided by the California Growth Study. The results of the factor analyses seemed exceptionally clear: "In some 15 years of factorial work this writer has never seen a more beautiful set of factor loadings; i.e., one that shows as much regularity as the one presented here." Of immediate interest for the present discussion is the finding that a factor III, present but overshadowed in earlier years, rises to account for a majority of the variance from age 5 onward. Hofstaetter interprets the factor by use of the terms "provisional action," "planning," and "abstract behavior."

E. Miscellaneous other Transitions

There remain, finally, some other reported transitions during this period which cannot be easily placed under a chapter heading, or which are more general in nature.

16. *Internalization of Speech*

Vygotsky (1962) has attached central importance to the period from 3–7 years of age, assuming that this is the age period when a portion of speech becomes the nucleus of abstract and symbolic thought. Presumably, the speech of the younger child is primarily a social tool for expressive and instrumental purposes. Toward the kindergarten years, speech becomes an instrument to regulate the self as well as the environment; the child talks to himself, effectively instructs himself, while problem-solving. This talking abates as the child grows older, bursting out from time to time when the child faces a particularly difficult situation. Such outbursts become progressively more incoherent to any other person. Such a sequence of events has led Vygotsky to suggest that speech is internalized in the age period from 3 to 7 to become an instrument of planning and representation.

17. *Shift to Paradigmatic Word Associations*

During this period, there is a noticeable alteration in the types of word associations which are elicited from children. At about age 7 children's word associations shift from "syntagmatic" (associations having a meaningful connection but not grammatical likeness) to "paradigmatic" (where the child's free associations tend to give adjective for adjective, noun for noun, verb for verb) (Ervin, 1961; Brown & Berko, 1960). The younger children tend to give associations which are phrase completions or clangs, the result of one kind of experience with words. The older children have acquired experience using words as parts of speech. They give the paradigmatic response "to send" to the stimulus "to mail" because the words are indirectly associated by what Ervin calls "forward contiguity." Both words have frequently been aroused by similar semantic and grammatical contexts.

18. *Increased Influence of Delayed Auditory Feedback*

Chase *et al.* (1961) have reported that children between 7 and 9 were more affected by delayed auditory feedback than were children between 4 and 6. That is, the speech of the older children was more distorted from the normal if they had to keep speaking while a tape recorder played their speech back to them after a brief delay interval. Delayed playback brought the speech

of the older children into generally greater conformity with the normal speech of the younger children. Most children indicated awareness of a difference between delayed and synchronous auditory feedback. Almost all younger children thought the voice under delayed feedback was "louder"; about half of the older children recognized that it was delayed.

There is some evidence suggesting that this age transition may be affected by pathology. Goldfarb and Braunstein (1958) have reported that schizophrenic children from 8–10 are less affected by delayed auditory feedback than are normal control subjects.

19. *Shift Toward Planning*

Some data of Hetzer (1926) indicate that there is a shift of verbalization toward a planning function during the ages from 3 to 6. Hetzer asked children to draw pictures. At 3 years of age, 90% of her children gave no verbal description of their drawings either before, during, or after drawing. At 4 and 5 years of age, most children named their drawings either before or during drawing. At 6 years of age, 100% of the children named before drawing.

20. *Hypothetical Maxima and Minima*

We will shortly consider some of the more general transitions during this period which have been reported by Piaget. An experiment by Rey, described by Piaget, seems worth indicating here where we are concerned with fairly particularized indications of transition.

"By way of example let us take an interesting experiment by our colleague, André Rey: a square with sides a few centimeters long is drawn on a sheet of paper which is also square (side 10–15 centimeters), and the subject is instructed to draw with a pencil the smallest square he can as well as the largest square which can be made on such a sheet. Now while adults (and children over the age of 7–8) succeed straight away in producing a square of 1–2 millimeters and one closely following the edge of the paper, children under the age of 6–7 at first draw only squares scarcely smaller and scarcely larger than the standard, and they proceed by successive, and often unsuccessful, trial-and-error, as if they at no time anticipated the final solutions" (Piaget, 1960c, p. 37).

21. *Transition from Social to Abstract Reinforcement*

Zigler (Zigler & Kanzer, 1962; Zigler, 1962, 1963) has suggested that children move from a concern with social rewards such as praise and attention to a concern for a more intellectual and abstract kind of reward, information that they have been correct. He gives no clear age range in which the transition

occurs, but we may infer that middle-class children have made the transition by age 7 while lower-class children have not all completed it (Zigler & Kanzer, 1962). This kind of transition, in this age range, is consistent with other indications in the general literature (cf. White, 1963). Some of the differences between normal and retarded children seem explainable in terms of differing reinforcer hierarchies (Zigler, 1962).

F. Summary Table of Age Changes from 5 to 7

The preceding pages have summarized a miscellany of behavior changes reported during the period from 5–7 years of age. Presentation of this aggregate of data has necessarily wandered from one topic to another; the changes as they are now known are disjointed and disconnected. Table III, summarizing the changes, may be useful for comparing them.

IV. Approaches to Interpretation

A. General Characteristics of the Research Literature

It is evident that there are a good number of behavior changes reported for the period under discussion, and it will shortly be evident that there is considerable precedent for the attribution of some significance to the age range. The array of evidence has been introduced to raise a specific point: to indicate that the changes in learning from 5 to 7 are part of a broad spectrum of change. Explanations of the learning data have, so far, not tried to take into account much of the other material though it may be essential (and certainly it should be useful) to do so. Some comments about the evidence are in order before we go on to consider implications.

It must be said again that most of the reported changes should be further substantiated and explored by follow-up work. Where a transition has been demonstrated in only one or two experimental formats, it may depend on unrecognized details of format, and our interpretation may be misleading or too general.

Further exploration of these age changes would serve, as well, to describe more carefully the central age and dispersion of each transition. The period from 5 to 7 appears to be modal for most of the transitional material—with individuals dispersing between 3 and 8 according to such variables as sex, socioeconomic class, and IQ.

Some of the transitions appear to complete themselves between 5 and 7; others appear to be just beginning in the age range. There is a blur in

any report of age change, because minor details of procedure may help or hinder children and, in effect, move the percent-passing curve back or forth 1 or 2 years on the age line. Research is needed to show which changes are coincident and which are not. Gaines (1963), for example, has reported

TABLE III
SUMMARY OF BEHAVIOR CHANGES FROM AGE 5 TO AGE 7

Younger pattern	Older pattern	Source
(1) Near but not far transposition	Near and far transposition	Kuenne (1946)
(2) Nonreversal shift easier	Reversal shift easier	Kendler & Kendler (1962a)
(3) Classical conditioning increasing	Classical conditioning decreasing	Razran (1933)
(4) Varying position hinders discrimination	Varying position helps discrimination	White (1965b)
(5) Varying positive cue hinders discrimination	Varying positive cue neutral	White (1965b)
(6) Little direct inference	Frequent direct inference	Kendler & Kendler (1962b)
(7) Simple discrimination improves	Simple discrimination declines	Weir & Stevenson (1962)
(8) Prefer tactual exploring	Prefer visual exploring	Schopler (1964)
(9) Color or mixed dominance	Form dominance	Brian & Goodenough (1929)
(10) No left-right sense	Personal left-right	Piaget (1959)
(11) Form, word, and letter reversals	Decline in reversals	Davidson (1934, 1935)
(12) Easily disoriented	Resists disorienting	Emerson (1931)
(13) Fails face-hand test	Passes face-hand test	Fink & Bender (1953)
(14) Increasing prediction of adult IQ	Maximal prediction of adult IQ	Bayley (1949)
(15) Factors I and II account for IQ	Factor III principal factor	Hofstaetter (1954)
(16) Speech expressive and instrumental	Speech internalized	Vygotsky (1962)
(17) Word associations syntagmatic	Word associations paradigmatic	Ervin (1961)
(18) Lesser effect of DAF	Greater effect of DAF	Chase *et al.* (1961)
(19) Little planning before drawing	Planning before drawing	Hetzer (1926)
(20) Difficulty drawing "largest" and "smallest" squares	Can perform task	Piaget (1960c)
(21) Reinforced by praise	Reinforced by correctness	Zigler & Kanzer (1962)

that form-dominance is related to superior discrimination learning (whether it involves forms or colors), and color-dominance to poorer discrimination learning. More such evidence should be sought.

What do these reported changes, in the whole, represent? One might speculate that the numbered entries in Table III represent transitions toward:

1. The use of language representations of stimuli as "pure stimulus acts," as second-order cues evoking behavior which the stimuli themselves would not call forth—(1), (2), (6), (9), (10), (12), (16).

2. The ability to maintain orientation toward invariant dimensions of stimuli in a surround of variance—(1), (4), (5), (12).

3. The ability to string together internal representations of stimulus-response-consequence into sequences which, projected into the future, allow planning and, projected into the past, allow inference—(6), (7), (15), (16), (19), (20).

4. Relatively more sensitivity to distance receptors of vision and audition, and relatively less sensitivity to near receptors of emotion, touch, pain, proprioception, and kinesthesis—(3), (8), (10), (12), (21).

Not all entries in Table III are well summarized by the four given rubrics. The transition may have important facets which are not yet clear. The summarizations suggest reasonable possible lines of unification of the disparate transitions. The first three rubics would seem to represent characteristics usually ascribed to "symbolic" or "abstract" thought, and are much like Hofstaetter's (1954) description of Factor III, indicated earlier. In emphasizing symbolization, they are much like interpretations of this transitional age period from other available sources.

B. Theoretical Conceptions of the Transition

The four major contemporary points-of-view concerning cognitive development have held the 5–7 period to be important, each on its own evidence and in its own terms.

Piaget

Piaget has reported many changes in cognitive function at age 7; this age for him is a transition point between major epochs of mental development. Some of those changes are indicated in Table IV; one or two others have been mentioned earlier. In his earlier writings Piaget identified lines of progression, and the cutting points which demark stages, in one type of cognitive behavior after another. Later writings, in effect, generalized the cutting points and the categories into a general schematization of cognitive development.

The many changes at age 7 were interpreted as indicating a major move from a stage in which the child operates by "intuitive" grasp of relations between objects (by representation of an action involving the two objects) to one in which these relations begin to be "grouped," and "concrete operations" become possible. The child is able to combine real and hypothetical relations

among objects to deduce others, and the deductions have a characteristically "obvious" quality to them (Piaget, 1960c). The reader is referred to Flavell's lucid and detailed presentation (Flavell, 1963, Chapters 4 and 5).

Some American investigators who have attempted to confirm Piaget's research material with nonverbal methods have argued that Piaget's emphasis on verbal questioning causes him to place changes at an older age, or to see them as more sudden than they appear when nonverbal methods are used (Braine, 1959, 1962; Yost *et al.*, 1962). It may be true that cognitive acquisitions are seen earlier on a nonverbal than on a verbal level, or perhaps nonverbal methods, quantitatively treated, show deflections before an epistemologist might judge that a child clearly "has" a communicable understanding.

TABLE IV

Some Developments at Age 7 Reported by Piaget

a. Conversations indicating collaboration in action between two children. b. Conversations indicating collaboration in abstract thought. c. Genuine argument. d. Avoidance of self-contradiction.	Piaget (1926)
e. Sharp increase in use of "because" and "since." f. Use of "but" and "then" in logical sense. g. Introspectiveness begins.	Piaget (1959)
h. Names treated as separate from things they represent.	Piaget (1960a)
i. Genuine physical explanations appear. j. Genuine awareness of need for causal agent.	Piaget (1960b)

Russian Theorists

Where Piaget has taken pains to describe the intellectual resources of the child at the terminus of the 5–7 period, the Russian material concentrates on processes leading into it. As Luria puts it:

"But it is interesting that we find a decisive turning point in all our experiments between the ages of 4 and 5 years. Something very important happens in the human being in this period. It is the period when speech is interiorized, when voluntary movements are developed and performed, and I think there must be some very intimate relation to maturation" (Luria, 1960b).

Russian interpretation of the transition essentially begins on Pavlov's premise that human mentation is an elaboration of the second signal system (language), which itself elaborates out of the first signal system, the level of classical conditioning. Some of the elaboration was worked out by Vygotsky (1962) as described earlier. Still further detail is given in a sequence of experiments described by Luria (1961). Quite early, it appears that speech can initiate

behavior in the child but it usually cannot regulate it, i.e., stop it or change it, when it is ongoing. Later, until the age of $4\frac{1}{2}$, it is possible to arrange matters so that speech can regulate behavior, but speech serves as only one of a class of exteroceptive stimuli which have this regulating power. It is the fact that a noise has been made, rather than what is said, which counts. When the content of utterances begins to have regulatory influence, speech simultaneously begins to shift from external to covert control, and the transition is entered upon.

S-R Theory

Until recently, an S-R interpretation of the transition had not been given at length; Kuenne's (1946) explanation of her own findings remained pretty much the general explanation for transition phenomena during the 5–7 period.

Recently, Kendler and Kendler (1962a) and Reese (1962) have advanced interpretations of the transition which are alike in most respects, and which resemble the Russian interpretation. The focal idea is that at the transition the child begins to be guided by a mediating response which he makes to a presenting stimulus as well as by the stimulus itself. The most important, but not the only, mediating response is the word. Although children can label cues before the transition point, the labeling is not brought to bear on problem-solving with the cues. In Reese's terms, the younger children have a "mediational deficiency," because overlearning of a word must take place before the word can mediate. In the Kendlers' terms, the act of mediating is one horizontal process, the act of responding another. Vertical connections between the horizontal processes are established by development—much as, in Vygotsky's terms, language and thought evolve separately and then unite. Older children can, given a vertical connection, use the word they generate to select responses; in so doing, their behavior becomes effectively conceptual (Kendler, 1964).

Freud

Freud's concern, of course, was not with cognition pure-and-simple, but rather with cognition as it determines transactions with the emotional environment. Of immediate interest is the fact that Freud's theory of psychosexual development (Freud, 1938b) again stresses transition between 5 and 7. Those years, for Freud, represent a time when the sequence of pre-genital stages has passed, when the Oedipal drama has been played through, and now (a) childhood sexuality is inhibited and the child enters into the latency period; (b) the parental sanctions are internalized to form the superego. The theme in both major events is inhibition. There is even inhibition of memories: "I refer

to the peculiar amnesia which veils from most people (not from all) the first years of their childhood, usually the first six or eight years" (Freud, 1938a, p. 581).

C. A Possible Synthesis

In one way or another Piaget, the Russian theorist, and the S-R theorists appear to share a belief that a widely ramified system of juvenile mental processes gives way to higher mental processes during the transition. Freud, on the other hand, argues that there is a new strong force of inhibition at transition. Vygotsky (1962) appears to bridge the two approaches; the parallel between his conception of the internalization of speech and Freud's conception of the internalization of sanctions is striking. Of course, the internalization of speech does not take place under threat; perhaps the internalization of conscience does not either. Perhaps the 5–7 period is a time when some maturational development, combining perhaps with influences in the modal environment, inhibits a broad spectrum of first-level function in favor of a new, higher level of function.

Let us put the idea more directly and in terms of learning. Suppose the child, before the transition, solves problems according to a set of processes which we generally describe as "associative," and that associative learning is one of the complex of factors determining the "before" sides of the transitions listed in Table III. The changes in the child's behavior from 5 to 7, unlike many other age changes, may not take place by enrichment, elaboration, smoothing, or by any process which transforms and irrevocably alters the original product. Perhaps, instead, a new level of function comes in having the four properties described in Section IV, A. We might generally characterize the higher level of function as "cognitive." It needs more detailed description. For the moment, we would like to argue only that the cognitive level of operation depends critically upon the inhibition of associative function or, at least, of the response which associative function is capable of determining.

The notion that classical conditioning and instrumental learning go on simultaneously in approach and avoidance learning is generally accepted. They can occur simultaneously because, by and large, they are directed to different classes of effectors, and probably involve different central circuits. The conception presented here implies that associative and cognitive layers are similarly parallel, but arranged in a competitive hierarchy in the child over seven.

Collateral evidence, to be discussed in the next section, suggests that two such layers are present in the adult, and that they compete in a temporally stacked structure like that presented earlier as a model structure derived from studies of competing S-R connections.

V. Some Collateral Evidence

We have, finally, to consider some theory and data which are in support of the hypothesis just advanced.

The thesis just advanced depends, for one thing, on a contention that children are poorer at response inhibition when they are younger. Luria (1961) has furnished evidence of this—again, his evidence is that younger children are initially able to follow commands which call for action but at the same time are unable to follow commands which demand restraint of ongoing action. Germane also is a finding by Spiker and White (1959) that $4\frac{1}{2}$–5-year-old children who have more exposure to experimentation solve a stimulus differentiation problem better because they are better able to inhibit responding to the negative cue. Younger children are poorer at restraining responses, and they are poorer at retaining a response over a delay interval (Collins, 1957; Tapp, 1957; Kaiman, 1958; Larsen, 1959).

The thesis demands, also, that children have difficulty restraining first-available responses in experiments like those used to suggest the model structure. There is considerable evidence that children are generally poorer at discrimination learning (though some exceptions have been noted above), some evidence that they generalize more (Mednick & Lehtinen, 1957; White & Spiker, 1960), but, as yet, no test of whether they show more associative interference.

Finally, the entire line of reasoning meets a body of theory and research primarily directed at adult thinking where layering is posited. Hilgard (1962) has recently reviewed evidence for layers of impulsive vs. realistic thinking in adults, layers which represent Freud's primary and secondary processes in thought. There is, in general, resemblance between the kinds of connections among ideas posited in Freudian primary process and those posited in classical Associationism.

Flavell (Flavell & Draguns, 1957; Flavell *et al.,* 1958) has argued that temporary or chronic mental pathology releases first-available, genetically older, responses which most adults usually suppress in favor of more conceptual, longer-latency responses. Werner (1957) has also advanced this "microgenetic" thesis, and has furnished evidence of some rather striking parallelisms in the trends of Rorschach indices as children move from younger to older, as one examines schizophrenics ranging from more to less severe pathology, and as adults are forced to deal with faster to slower tachistoscopic presentations. It is, of course, not clear why a fast tachistoscopic exposure should necessarily cause the adult to revert to first-available responses, but the present point is that here we have a case where "younger" responses are available to the adult and have somehow been brought out.

Double-edged evidence, for and against the present hypothesis, is reviewed

by Woodworth and Schlosberg (1954). A scale of superficiality of word associations is given in which the most superficial associations are clearly of the sort which could be characterized as associative: phrase completions, word compounding, and clangs. In favor of the current hypothesis are reported findings that adults revert to superficial associations under conditions of distraction, fatigue, and alcohol. Against the hypothesis is cited evidence that adults given practice in word associations, and 9–14-year-old boys given repeated retests, tend to become more superficial.

One might conjecture, in defense, that there may be a "law of least mental effort" under which adults, after some exposure to a situation, revert to associative function if they feel safely able to do so. The conjecture is not inconsistent with everyday experience. We say of boring tasks, "My mind wandered," or "I can't keeep my mind on it." Perhaps associative function constitutes an automation system for often repeated behavior; one may recall William James's habit, "the great flywheel."

The work of Kagan *et al.* (1963) should be mentioned, because here individual differences in cognitive style having broad ramifications in behavior have been identified, at least in boys, with motoric impulsivity and hyperkinesis. Given the kinds of cognitive performances characteristic of analyzers and nonanalyzers, more or less impulsive types, the differences between them might be linked to predominantly associative and cognitive function as defined here.

Mention should be made of an interesting book by Diamond *et al.* (1963), which develops the thesis that cognitive processes (essentially, all the ramifications of the act of choice) depend critically upon series of systems of neurophysiological inhibition. The writer believes that the terms "response inhibition" and "neural inhibition" have some connection which is more than metaphor and that the transition discussed here will, ultimately, be shown to involve corticalization. The general idea of higher and lower functional levels of behavior mediated by higher and lower brain structures is, of course, very old. It is discussed in an interesting way by Luria (1960a).

VI. Concluding Comments

In sum, it is suggested that the data on temporal contingencies in learning, and the material on the various shifts in the 5–7-age period, may define something about the structure of adult mental processes. Adults may have available an "associative level," laid down early in development, relatively fast acting, followed conventional associative principles, and in the normal adult relatively often existing as a potential, but inhibited, determinant of behavior. The "cognitive layer," laid down after the associative mode of response, is taken to be relatively slower in action and to process information

in ways which are only beginning to be understood. These two levels are taken to be temporally stacked, the faster associative mode having precedence over the cognitive mode, and conditions which influence a subject's tempo of response and/or his ability to restrain a first-available response will influence which mode determines his response.

The building of the second, cognitive layer either begins, or is most marked, in the period from 5–7. At that time, many small signs of transition are seen. Surely, the move does not take place in one giant step, but the coincidence or sequencing of all the little steps has not yet been investigated and needs to be. The fact that children begin school at age 6 is an important unknown factor. It could at the same time be a cause of the transition and a historical consequence of the potentiality for it at that age. Perhaps cross-cultural replications of these transitions should be sought in cultures in which children do not enter school at age 6.

It is a curious and interesting fact that the history of psychology shows an almost continuous reissue of an essentially associative scheme of thought and, in each epoch, strong rejection of that associative scheme by a dissident group. There was the conflict between the British Empiricist-Associationists and the Scotch Faculty School, between Wundt and the Brentano-Würtzburg axis, and, in our own century, between S-R and Gestalt. It might be suggested that this extraordinarily persistent argument may reflect, in part, the paradoxical fact that human behavior may or may not follow associative laws closely, depending upon eliciting conditions.

In view of some of the collateral findings which have been discussed, it might also be suggested that some cognitive changes induced by stress may be regressive, in the sense that these changes reflect the disinhibition of first-available associative function. This is not to suggest that the stressed adult reverts to his childish cognitions. The associative level should continue learning, according to its own laws, after age 7. It could claim responses developed by the cognitive system and practiced. The stressed adult might revert to a more sophisticated, more grown up, better-developed version of the associative system which young children also favor.

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SELECTED ANATOMIC VARIABLES ANALYZED FOR INTERAGE RELATIONSHIPS OF THE SIZE-SIZE, SIZE-GAIN, AND GAIN-GAIN VARIETIES

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I. Introduction

This chapter surveys facets of knowledge concerning three types of anatomic correlation within the segment of human ontogeny between birth and early adulthood. Its sole concern is with interage or interstage associations. To illustrate: body stature is analyzed by considering (a) magnitude at selected ages in relation to magnitude at subsequent ages, (b) magnitude at selected ages in relation to increment during subsequent periods, and (c) increment during periods in relation to increment in succeeding periods.

Excluded from consideration are intertrait associations, i.e., correlations specific for age, stage, or period which provide information on the directions and strengths of bivariate and multivariate relations such as magnitude of trunk dimensions with magnitude of limb dimensions (Meredith, 1939a; O'Brien, Girshick, & Hunt, 1941; Tuddenham & Snyder, 1954; Kasius, Randall, Tompkins, & Wiehl, 1957) or increment in cephalic dimensions with increment in thoracic dimensions (Kasius *et al.*, 1957; Meredith, 1962).

II. Interage (Interstage) Relationships for Stature

A. Background Information

Stature is defined as the maximum rectilinear distance from the vertex of the head to the soles of the feet. Details of procedure in positioning the subject and determining this distance are discussed elsewhere (Krogman, 1950; Meredith, 1960). Here it will suffice to indicate that stature can be measured with high reliability; methodological studies for newborn infants and for individuals at given postnatal ages between infancy and adulthood yield reliability coefficients exceeding $r = .90$ (Marshall, 1937; Knott, 1941; Meredith & Goodman, 1941; Newcomer & Meredith, 1951).

At birth, infants vary in prenatal age; from a sample of 763 normal infants, Gibson and Dougray (1953) find the standard deviation of the distribution for duration of the prenatal period to exceed 10 days. Prenatal age and stature at birth are positively correlated; Cawley, McKeown, and Record (1954), from a sample of 641 normal infants, report $r = .33$ for length of gestation and neonatal stature. With birth rank and maternal age constant, $r = .31$. Corresponding r's for length of gestation and stature 1 year after birth show decline to .13 and .10, respectively.

The distribution of human stature in groups homogeneous for race, generation, sex, and postnatal age is bell-shaped and closely approximates the normal-

frequency model (Keyfitz, 1942; Blommers & Lindquist, 1960). On North American white children specific for sex and secular decade, standard deviations for stature approximate 2.0 cm at birth (Kasius *et al.*, 1957), 3.3 cm at age 2 years (Meredith, 1943), and 5.5 cm at age 6 years (O'Brien *et al.*, 1941). The increase in variability continues until early adolescence, reaching about 7.4 cm at age 12 years for females and 8.6 cm at age 14 years for males. There follows a late adolescent decline in variability which rests at approximately 5.8 cm for young adult females and 6.3 cm for young adult males (O'Brien *et al.*, 1941; Meredith, 1935).

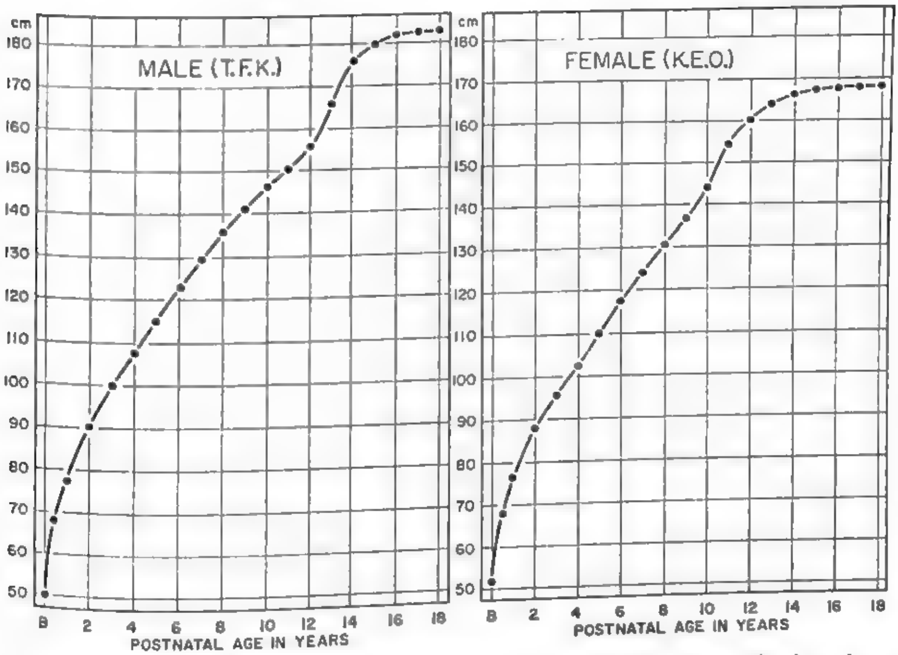

Fig. 1. Individual curves for magnitude of stature at ages between birth and early adulthood.

The trend of the curve for human stature over the first 20 years of postnatal life has been known almost two centuries (Scammon, 1927). In Fig. 1 are plotted stature data for 1 male (T.F.K.) and 1 female (K.E.O.); it will be seen that both curves ascend rapidly in infancy, rise at a slowing pace throughout childhood, ascend fairly rapidly in early adolescence, and approach maximum in late adolescence. Mean age of the circumpuberal acceleration is fully 2 years earlier in females than males, and within each sex there is a 5-year spread in timing of the acceleration for different individuals (Meredith, 1939b).

B. Size-Size Associations

The correlation of stature measured at birth and remeasured 1 year after birth is available from studies by Simmons and Todd (1938), Low (1952), Kasius *et al.* (1957), and Reed and Stuart (1959). Sample size for these studies is 103, 126, 382, and 124, respectively. Subjecting sex specific r's from the four sources to synthesis by z-transformation gives the composite statistic, $r = .52$ (weighted $z = .57 \pm .04$).

For stature at postnatal ages 1 month and 1 year, sex specific coefficients are accessible from Maresh and Washburn (1938), Norval, Kennedy, and Berkson (1951), and Falkner (1958). Combination of these statistics yields N = 859, weighted z = .48, $r = .44$.

Coefficients expressing stature relationships for successively paired annual ages between 1 year and 5 years were assembled for combination as follows:

Ages 1 and 2 years, from Bayley and Davis (1935), Maresh and Washburn (1938), Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), Falkner (1958), and Meredith (1961a). N's are 43, 51, 93, 126, 115, 120, and 237, respectively.

Ages 2 and 3 years, from Bayley and Davis (1935), Maresh and Washburn (1938), Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 43, 45, 250, 126, 136, and 147, respectively.

Ages 3 and 4 years, from Maresh and Washburn (1938), Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 33, 269, 126, 136, and 194, respectively.

Ages 4 and 5 years, from Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 258, 126, 136, and 365, respectively.

The composite coefficients, derived as before through z-transformation of r's specific for sex, are shown in the upper left portion of Table I. There is increasing positive association with age over the first quinquennium of postnatal life. The weak association for stature at the beginning and end of the first postnatal year ($r = .52$) rises in successive years, becoming a strong association for stature at the limits of the fifth postnatal year ($r = .96$). Measures of stature representing consecutively paired annual ages continue to exhibit strong positive association throughout later childhood (Simmons, 1944; Tuddenham & Snyder, 1954).

In the upper right portion of Table I are correlation coefficients for magnitude of stature at young ages separated by intervals of 3, 4, and 5 years. These statistics were obtained by amalgamating component r's as follows:

Birth and age 5 years, from Low (1952). Utilizing longitudinal data for stature published in this source, sex specific r's were computed by the writer.

Ages 1 and 5 years, from Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 126, 115, and 69, respectively.

Ages 2 and 5 years, from Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 177, 126, 136, and 79, respectively.

Ages 5 and 9 years, from Tuddenham and Snyder (1954) and Meredith (1961a). N's are 136 and 364, respectively.

Ages 7 and 11 years, from Meredith (1936), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 263, 66, and 155, respectively.

Knowledge of a child's stature at birth is of little value for predicting his stature at age 5 years. When $r = .30$, the standard error of estimating Y for a given X is smaller than the standard deviation of Y by barely 5%. To elucidate: (a) lacking information on the relation between stature at birth and 5 years, the "best guess" regarding any individual's stature at 5 years is the mean stature for this age, and (b) given $r = .30$, the long-run improvement in prediction of stature at 5 years from stature at birth is 4.6% (Guilford, 1950; Blommers & Lindquist, 1960).

Forecasting efficiency is higher in estimating stature at age 5 years from stature in late infancy. The standard deviation of Y (which in forecasting becomes the standard error of estimates when r is zero or unknown) is reduced approximately 24% for predictions based on knowledge of stature at age 1 year ($r = .65$) and approximately 41% for predictions based on knowledge of stature at age 2 years ($r = .81$).

There is high positive association between stature in middle childhood and stature in late childhood. From poolings of sex specific coefficients on both sexes, $r = .92$ for stature at ages 5 years and 9 years (Table I) and $r = .96$ for stature at ages 6 years and 9 years. The latter figure is the composite correlation for 1,067 North American white children, 465 from Dearborn, Rothney, and Shuttleworth (1938), 136 from Tuddenham and Snyder (1954), and 466 from Meredith (1961a). Studies by Wilson (1935) on 275 females, and Tuddenham and Snyder (1954) on 70 females, each obtained $r = .96$ from correlating stature at ages 7 years and 10 years. On males only, $r = .93$ for stature at ages 6 years and 11 years (as derived from Dearborn *et al.*, 1938; Tuddenham & Snyder, 1954; Meredith, 1961a), and $r = .96$ for stature at ages 7 years and 11 years (Table I). Component N's for the 6-with-11 coefficient are 228, 66, and 166, respectively.

The high consistency of rank order in stature from middle childhood to late childhood is not maintained in adolescence. As a consequence of individual differences in the timing and magnitude of the circumpuberal stature spurt,

children near average stature in middle childhood sometimes become tall or short in adolescence and, conversely, children tall or short in middle childhood sometimes shift rank in adolescence to near the center of the stature distribution for their sex peers (Meredith, 1939b). Assembled in the middle portion of Table I are coefficients quantifying these statements by correlation method.

The crest of the circumpuberal hump in the velocity curve for mean stature is reached by females near age 12 years and by males near age 14 years. Rows 6 and 7 of Table I show (a) $r = .83$ on females for stature at ages 6 and 12 years, (b) $r = .79$ on males for stature at ages 6 and 14 years, and (c) $r = .67$ on both sexes for stature at these adolescent ages with stature in early adulthood. The index of forecasting efficiency, which exceeds 70% in using stature at 6 years to predict stature at 9 years ($r = .96$), is less than 50% in using stature at 6 years to predict stature at 12 years (females) or 14 years (males), and is less than 30% in using stature at 12 years (females) or 14 years (males) to predict stature in early adulthood.

For individuals of each sex, age at which stature reaches circumpuberal peak velocity has a range exceeding 5 years. Circumpuberal peak velocity for the individual may be taken as reference in determining (a) stature at this stage and (b) age at this stage. Poolings of sex specific correlation coefficients yield $r = .78$ for stature at age 6 years with stature at circumpuberal peak velocity (SCPV) and $r = .90$ for stature at circumpuberal peak velocity with stature in early adulthood. The latter coefficient registers positive relationship sufficiently high to yield a predictive index (reduction in the standard errors of estimate) near 55%.

The obtained correlation from combining sex specific coefficients for stature at age 6 years with age at circumpuberal peak velocity is $r = —.26$. This low negative association registers a weak tendency for children tall in middle childhood to undergo their adolescent acceleration earlier than those short in middle childhood. Notwithstanding, a relation giving an index of forecasting efficiency below 4% has negligible predictive usefulness.

Age of circumpuberal peak velocity of stature (ACPV) and magnitude of early adult stature (EAS) are largely independent variables. The tabled $r = .01$ allows, at the 1% confidence level, statistical inference that the population coefficient lies between $r = —.10$ and $r = +.10$. Research by Boas (1932) and Shuttleworth (1939), employing the method of determining stature means in early adulthood for several ACPV subgroups, indicates that means from subgroups having early acceleration are similar to those from subgroups having late acceleration. The near zero coefficient from use of correlation method supports the conclusion of Boas that timing of the circumpuberal stature acceleration "has no appreciable influence upon adult stature."

Sources drawn upon for deriving the statistics presented in the middle portion of Table I are:

TABLE I

CORRELATION OF HUMAN STATURE AT DIFFERENT AGES OR STAGES BETWEEN BIRTH AND EARLY ADULTHOOD

Age (years) or stage	N	r^a	Age (years) or stage	N	r^a
		Infancy through childhood			
Birth with 1	735	.52	Birth with 5	126	.30
1 with 2	785	.82	1 with 5	310	.65
2 with 3	747	.89	2 with 5	518	.81
3 with 4	758	.93	5 with 9	500	.92
4 with 5	885	.96	7 with 11[b]	484	.96
		Childhood through adolescence			
6 with 12[c]	532	.83	12 with EAS[d]	747	.67
6 with 14[e]	384	.79	14 with EAS	517	.67
6 with SCPV[f]	744	.78	SCPV with EAS	686	.90
6 with ACPV[g]	744	−.26	ACPV with EAS	686	.01
		Infancy and childhood with early adulthood			
Birth with EAS	214	.31	2 with EAS	256	.69
0.25 with EAS	162	.32	4 with EAS	291	.78
1 with EAS	408	.62	6 with EAS	708	.79

[a] Composite correlation coefficients derived from series of sex specific r's using z-transformation. Except as indicated, each pooling of r's is for both sexes.

[b] Males only. Many females commence their circumpuberal acceleration in stature during the biennium between ages 9 and 11 years; among males, comparable modification of the childhood stature trend rarely occurs prior to age 11 years.

[c] Females only throughout this row.

[d] EAS symbolizes early adult stature and connotes measurement when the individual has reached or is approximating maximum stature (in this connection, see Boas, 1932; Shuttleworth, 1939; Clements, 1954).

[e] Males only throughout this row.

[f] SCPV denotes stature of the individual at the time of circumpuberal peak velocity.

[g] ACPV symbolizes age when circumpuberal peak velocity is attained. All coefficients other than those in this row are size-size r's.

Ages 6 and 12 years, Dearborn *et al.* (1938), Simmons (1944), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 231, 81, 70, and 150, respectively. Longitudinal stature records from Dearborn *et al.* were plotted, read off at the ages desired, and analyzed by the writer.

Ages 6 and 14 years, Dearborn *et al.* (1938), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 228, 66, and 90, respectively. Correlation coefficients for Dearborn *et al.* were obtained as above.

Age 6 years and SCPV, Dearborn *et al.* (1938), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 426, 136, and 182, respectively. All component r's were computed by the writer.

Age 6 years and ACVP, Dearborn *et al.* (1938), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 426, 136, and 182, respectively. Component r's were computed as above.

Age 12 years and EAS, Shuttleworth (1939), Simmons (1944), Bayley (1954), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 493, 72, 19, 70, and 93, respectively.

Age 14 years and EAS, Shuttleworth (1939), Simmons (1944), Bayley (1954), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 246, 77, 21, 66, and 107, respectively.

SCPV and EAS, Dearborn *et al.* (1938), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 392, 136, and 158, respectively. All component *r*'s were calculated by the writer.

ACPV and EAS, Dearborn *et al.* (1938), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 392, 136, and 158, respectively. Component *r*'s were calculated as above.

The bottom portion of Table I deals with stature at selected infancy and childhood ages in relation to early adult stature. Sex specific *r*'s were amassed for synthesis by weighted z-transformation from the following sources:

Birth with EAS, from Tanner, Healy, Lockhart, Mackenzie, and Whitehouse (1956), Reed and Stuart (1959), and McCammon and Hansman (1964). N's are 80, 124, and 10, respectively. The *r*'s reported by Tanner *et al.* were combined with *r's* obtained on pooling records from the other sources.

3 months with EAS, from Bayley (1954), Tuddenham and Snyder (1954), and McCammon and Hansman (1964). N's are 46, 93, and 23, respectively.

1 year with EAS, from Bayley (1954), Tuddenham and Snyder (1954), Tanner *et al.* (1956), Reed and Stuart (1959), and McCammon and Hansman (1964). N's are 40, 115, 80, 134, and 39, respectively.

2 years with EAS, from Bayley (1954), Tuddenham and Snyder (1954), and Tanner *et al.* (1956). N's are 40, 136, and 80, respectively.

4 years with EAS, from Bayley (1954), Tuddenham and Snyder (1954), Tanner *et al.* (1956), and Meredith (1961a). N's are 40, 136, 80, and 35, respectively.

6 years with EAS, from Dearborn *et al.* (1938), Bayley (1954), Tuddenham and Snyder (1954), Maresh (1955), and Meredith (1961a). N's are 392, 40, 136, 28, and 112, respectively.

There is not a high relationship between stature at infancy or childhood ages and stature in early adulthood. The obtained correlation coefficients listed in the lower part of Table I indicate that early adult stature correlates about $r = .30$ with stature at birth, $r = .60$ with stature at the end of the first postnatal year, $r = .70$ with stature at age 2 years, and $r = .80$ with stature at age 6 years. In respect to the weak association of neonatal stature and adult stature, it can be stated: ". . . a child may, over a period of years, shift from high to average, to low . . . compared with his age peers" (Bayley, 1956). The moderate positive association for stature at age 2 years with early adult

stature has limited predictive usefulness on individuals, since improvement upon "best guess" procedure is less than 30%.

C. Size-Gain Associations

Magnitude of stature at age or stage T_2 can be viewed as the combination of (a) magnitude of stature at age or stage T_1 and (b) increment of stature during the interval between T_1 and T_2. Taking this view, size-size *r*'s are part-whole coefficients and size-gain *r*'s are part-remainder coefficients (Guilford, 1950; Meredith, 1955a). Size-gain correlation, in other words, is a procedure whereby the Y-variable is freed from the confounding present in size-size correlation.

The biologist finds it meaningful to consider increments expressed in absolute (e.g., centimeter) and relative (e.g., percentage) terms (Minot, 1891; Meredith, 1935; Fisher, 1950). As emphasized over 70 years ago by Minot (1891), two increments of 5 cm each, although equivalent absolute quantities, may transpose to markedly different relative quantities. This is shown on increasing a stature of 50 cm by 5 cm (10%) and increasing another stature of 125 cm by 5 cm (4%). All relative increments utilized in this chapter are derived by expressing absolute gain during a specific interval as a percentage of attained size at the beginning of the interval. With particular reference to the present section and Section II, D, absolute gain is centimeter increase in stature from T_1 to T_2, and relative gain is percentage increase in respect to magnitude of stature at T_1.

At no age in infancy, childhood, or adolescence is magnitude of stature highly related to velocity of change in stature. Examination of the size-gain coefficients assembled in Table II shows all of them to fall within the limits —.65 and +.45.

There is low negative association between neonatal stature and increment in stature during infancy. Thompson (1956) obtained $r = -.44$ (N = 230) for magnitude of stature 2 weeks after birth and centimeter gain in stature during the ensuing 6-month period. The comparable value from Table II for neonatal stature and stature increment in the first postnatal year is $r = -.30$. Continuing reduction of the negative association throughout infancy, moving to zero correlation in early childhood, is exhibited by the Table II *r*'s from both absolute and relative increments.

Size-gain findings for stature in infancy can be set in broader biological perspective. Section II, A called attention to a weak tendency for short neonates to be younger than long neonates. In the present section a weak tendency is found for short neonates to augment stature during infancy at a faster rate than long neonates. The two low relationships mesh on recognition that the

velocity trend for stature on age is declining rapidly over the fetal and infancy segment of ontogeny.

During middle and late childhood magnitude of stature has low positive relation with absolute stature increase, and zero relation with relative stature increase. These findings are documented by (a) the statistics displayed in rows 5–7 of Table II and (b) *r*'s of .42 (size and centimeter gain) and —.07 (size and percentage gain) from Meredith and Meredith (1958). The latter *r*'s, based on a sample of 100 males, are for stature at age 5 years with increments for the subsequent sexennium.

TABLE II

CORRELATION OF HUMAN STATURE AT SELECTED ONTOGENETIC AGES OR STAGES WITH GAIN IN STATURE DURING SUBSEQUENT PERIODS

Row number	Age (years) or stage	Subsequent period	Size and centimeter gain		Size and percentage gain	
			N	r^a	N	r^a
1	Birth	Birth to 1	578	−.30	285	−.58
2	1	1 to 2	647	−.13	529	−.41
3	1	1 to 5	310	−.08	310	−.42
4	2	2 to 3	702	−.01	454	−.23
5	4	4 to 5	875	.24	627	−.05
6	5	5 to 9	500	.41	500	.04
7	6	6 to 9	1067	.45	1067	.03
8	6	6 to 12[b]	454	.37	454	.01
9	6	6 to 14[c]	384	.42	384	.10
10	6	6 to SCPV[d]	744	.06	744	−.33
11	Birth	Birth to EAS[e]	134	.04	134	−.65
12	1	1 to EAS	288	.21	288	−.37
13	4	4 to EAS	171	.23	171	−.28
14	6	6 to EAS	640	.07	640	−.44
15	SCPV	SCPV to EAS	686	−.19	686	−.42

[a] Composite correlation coefficients derived from series of sex specific *r*'s using z-transformation. Except as indicated, each pooling of size-gain *r*'s is for both sexes.
[b] Females only.
[c] Males only.
[d] SCPV denotes stature of the individual at the time of circumpuberal peak velocity.
[e] EAS symbolizes early adult stature.

Attained stature at age 6 years is (a) uncorrelated with absolute gain in stature from age 6 years to circumpuberal peak velocity, and (b) negatively associated with percentage gain from age 6 years to circumpuberal peak velocity (see Table II, row 10). The negative association, implying greater relative increment among short than tall 6-year-old children, is weak ($r = -.33$), affording a forecasting efficiency index under 6%.

The strongest size-gain relationship obtained is $r = -.65$ for stature at birth with percentage gain in stature from birth to adulthood (Table II, row 11). Study of the r's for size and percentage gain in rows 1, 2, 6, 7, 10, and 15 indicates that this negative correlation is compounded from negative associations in infancy and adolescence.

As in Table I, each of the Table II coefficients is a composite r derived, using the method of z-transformation, from sex specific r's on two or more samples. For the right-hand part of the table (size and percentage gain) N's were drawn as follows:

Row 1, 25 from Meredith (1943), 126 from Low (1952), 124 from Reed and Stuart (1959), and 10 from McCammon and Hansman (1964).

Row 2, 51 from Maresh and Washburn (1938), 126 from Low (1952), 115 from Tuddenham and Snyder (1954), and 237 from Meredith (1961a).

Row 3, 126 from Low (1952), 115 from Tuddenham and Snyder (1954), and 69 from Meredith (1961a).

Row 4, 45 from Maresh and Washburn (1938), 126 from Low (1952), 136 from Tuddenham and Snyder (1954), and 147 from Meredith (1961a).

Row 5, 126 from Low (1952), 136 from Tuddenham and Snyder (1954), and 365 from Meredith (1961a).

Row 6, 136 from Tuddenham and Snyder (1954) and 364 from Meredith (1961a).

Row 7, 465 from Dearborn *et al.* (1938), 136 from Tuddenham and Snyder (1954), and 466 from Meredith (1961a).

Row 8, 234 from Dearborn *et al.* (1938), 70 from Tuddenham and Snyder (1954), and 150 from Meredith (1961a).

Row 9, 228 from Dearborn *et al.* (1938), 66 from Tuddenham and Snyder (1954), and 90 from Meredith (1961a).

Row 10, 426 from Dearborn *et al.* (1938), 136 from Tuddenham and Snyder (1954), and 182 from Meredith (1961a).

Row 11, 124 from Reed and Stuart (1959) and 10 from McCammon and Hansman (1964).

Row 12, 115 from Tuddenham and Snyder (1954), 134 from Reed and Stuart (1959), and 39 from McCammon and Hansman (1964).

Row 13, 136 from Tuddenham and Snyder (1954) and 35 from Meredith (1961a).

Row 14, 392 from Dearborn *et al.* (1938), 136 from Tuddenham and Snyder (1954), and 112 from Meredith (1961a).

Row 15, 392 from Dearborn *et al.* (1938), 136 from Tuddenham and Snyder (1954), and 158 from Meredith (1961a).

N's and sources for the columns of Table II pertaining to size and centimeter gain are the same as above with the following additions:

Row 1, 105 from Simmons and Todd (1938) and 188 from Thompson

(1956). Thompson's r's are based on data for stature measured 2 weeks after birth (X-values) and centimeter increment in stature between 2 weeks and 1 year (Y-values).

Row 2, 118 from Simmons and Todd (1938).

Rows 4 and 5, 248 from Simmons and Todd (1938) in each row.

D. Gain-Gain Associations

Findings pertaining to relations between stature increments for paired segments of ontogeny are compiled in Table III. This table supplies no support for the proposition that there is high correlation of increase in stature during a given portion of infancy or childhood and increase in stature during ensuing portions of infancy, childhood, or adolescence.

TABLE III

Correlation of Increment in Human Stature during Selected Ontogenetic Periods and Increment during Subsequent Periods

Row number	Earlier period	Later period	Centimeter increments		Percentage increments	
			N	r^a	N	r^a
1	Birth to 1	1 to 2	144	.16	144	−.01
2	1 to 3	3 to 5	299	.00	299	−.09
3	3 to 5	5 to 9	185	.40	185	.20
4	6 to 9	9 to 11[b]	460	.51	460	.32
5	6 to 9	9 to SCPV[c]	744	−.26	744	−.26
6	Birth to 1	1 to EAS[d]	134	.20	134	−.01
7	1 to 5	6 to EAS	115	.11	115	−.17
8	6 to 9	9 to EAS	640	−.15	640	−.19

[a] Composite correlation coefficients derived from series of sex specific r's using z-transformation. Except as indicated, each pooling of gain-gain r's is for both sexes.

[b] Males only.

[c] SCPV denotes stature of the individual at the time of circumpuberal peak velocity.

[d] EAS symbolizes early adult stature.

Examined in respect to ascending magnitude of r, Table III yields three statements. Coefficients are between ±.20 from correlating stature increments for the first and second postnatal years (row 1), the first postnatal year and the period from late infancy to early adulthood (row 6), the bienniums 1 to 3 years and 3 to 5 years (row 2), the quadrennium 1 to 5 years and the period from middle childhood to early adulthood (row 7), also the triennium 6 to 9 years and the succeeding decade (row 8). There are low negative relationships

for stature increments in the triennium 6 to 9 years with those in the periods from 9 years to circumpuberal peak velocity (row 5) and early adulthood (row 8). Low to moderate positive associations occur in middle and late childhood (rows 3 and 4), the highest obtained r's (.51 from absolute increases and .32 from relative increases) representing, on males, the adjacent age periods 6 to 9 years and 9 to 11 years.

Other gain-gain correlations for stature from the literature include $r = -.13$ for centimeter increase in the first and second quarters of the first postnatal year (Kasius *et al.*, 1957), $r = -.13$ for centimeter increase in the first and last halves of the first postnatal year (Kasius *et al.*, 1957), and $r = .13$ for centimeter increase in the infancy periods 1 to 3 months and the first half of the second postnatal year (Falkner, 1958). These coefficients are based on N's of 372, 372, and 114, respectively.

N's and sources for the composite statistics of Table III are as follows:

Row 1, 18 from Meredith (1943) and 126 from Low (1952).

Row 2, 126 from Low (1952), 115 from Tuddenham and Snyder (1954), and 58 from Meredith (1961a).

Row 3, 136 from Tuddenham and Snyder (1954) and 49 from Meredith (1961a).

Row 4, 228 from Dearborn *et al.* (1938), 66 from Tuddenham and Snyder (1954), and 166 from Meredith (1961a).

Row 5, 426 from Dearborn *et al.* (1938), 136 from Tuddenham and Snyder (1954), and 182 from Meredith (1961a).

Row 6, 124 from Reed and Stuart (1959) and 10 from McCammon and Hansman (1964).

Row 7, 115 from Tuddenham and Snyder (1954).

Row 8, 392 from Dearborn *et al.* (1938), 136 from Tuddenham and Snyder (1954), and 112 from Meredith (1961a).

III. Interage Relationships for Body Weight

A. Background Information

As noted in Section II, A, normal infants (those not designated "premature") differ in age at birth, some being more than 6 weeks older than others. Age at birth and birth weight are positively related; Karn and Penrose (1951–52) report $r = .40$, on a sample of 13,116 neonates, and Cawley *et al.* (1954), on a sample of 641 neonates, report $r = .35$ when birth order and maternal age are held constant. The correlation for duration of the prenatal period and body weight at the end of the first postnatal year is slight, approximating $r = .10$ (Cawley et al., 1954).

Longitudinal records for body weight on 1 male (T.F.K.) and 1 female (K.E.O.) are plotted in Fig. 2. Following a neonatal decline too short for registration in Fig. 2 (Meredith & Brown, 1939), the trend for human body weight shows over-all ascent to early adulthood. This ascent takes place at velocities which decrease in infancy and early childhood, are fairly constant in middle childhood, increase during early adolescence, and decrease during late adolescence. In common with stature, mean age of the circumpuberal spurt

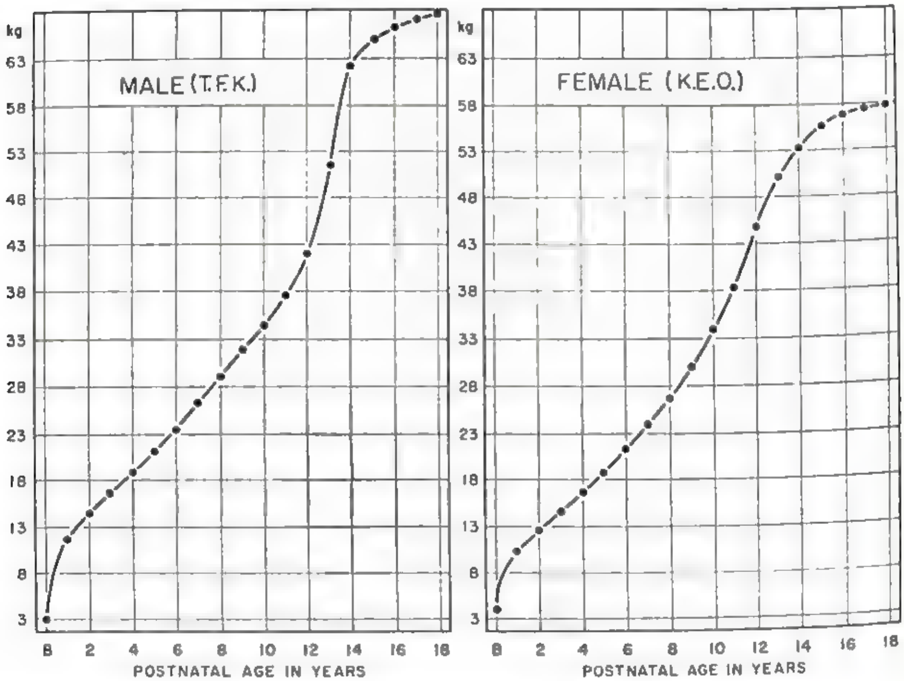

Fig. 2. Individual curves for magnitude of body weight at ages between birth and early adulthood.

is earlier for females than males by a biennium, and within each sex there is an age spread exceeding 5 years for timing of the spurt in different individuals. Total increment between birth and 20 years of age is much greater for body weight than for stature; stature rarely increases to 4 times its neonatal value, whereas means for body weight from recently drawn North American white samples increase to 16 (females) and 20 (males) times neonatal value.

Standard deviations for body weight on North American white children increase from slightly less than 0.5 kg at birth (Bakwin & Bakwin, 1934; Kasius *et al.*, 1957), through 3.2 kg near age 7 years (Meredith, 1935; Boynton, 1936), to 7.7 kg at age 13 years on females and 9.0 kg at age 15

years on males (O'Brien *et al.*, 1941). There is slight decrease in absolute variability during late adolescence.

Human body weight is markedly more variable than human stature. At ages within the period from birth to early adulthood, the coefficient of relative variation (Guilford, 1950) lies between the limits of 3% and 6% for stature, and between the limits of 9% and 20% for body weight (Bakwin & Bakwin, 1934; Boynton, 1936).

Distributions of human body weight on groups homogeneous for race, sex, generation, and postnatal age are "skewed positively," the asymmetry increasing from mild manifestation in infancy to pronounced manifestation in adolescence (Boynton, 1936; Keyfitz, 1942; Blommers & Lindquist, 1960). Gaussian normality is not assumed in utilization of r as a measure of relationship, but is assumed in prediction when use is made of the standard error of estimate.

As throughout Section II, correlation coefficients for presentation in this section were synthesized under two statistical cautions: (1) prior to amassing component r's, representative scatter diagrams were inspected for approximate linearity of regression, and (2) prior to combining r's on males and females, the sex specific coefficients were examined for similarity.

B. Size-Size Correlations

This subsection colligates part-whole associations for body weight. Its basic data for records on individuals from repeated weighings separated by intervals ranging from 6 months to 18 years. Table IV displays the quantitative findings derived on the topic.

Component r's used for the portion of the table allocated to infancy and early childhood were assembled as follows:

Birth and 6 months, from Bayley and Davis (1935), Herdan (1954), Tuddenham and Snyder (1954), Karn (1956), and Kasius *et al.* (1957). N's are 56, 160, 133, 114, and 711, respectively.

Birth and 1 year, from Simmons and Todd (1938), Simpson (1952), Norval *et al.* (1951), Hammond (1952), Low (1952), Tuddenham and Snyder (1954), Karn (1956), Kasius *et al.* (1957), Millis and Cho-Yook (1957), and Reed and Stuart (1959). N's are 154, 1,000, 1,007, 425, 126, 133, 114, 432, 102, and 130, respectively.

Ages 1 and 2 years, from Bayley and Davis (1935), Maresh and Washburn (1938), Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 47, 52, 233, 126, 133, and 237, respectively.

Birth and 3 years, from Low (1952), Cullumbine (1953), Tuddenham and

Snyder (1954), and Karn (1956). N's are 126, 327, 133, and 114, respectively.

Birth and 5 years, from Low (1952), Tuddenham and Snyder (1954), and Karn (1956). N's are 126, 133, and 114, respectively.

Ages 2 and 5 years, from Simmons and Todd (1938), Low (1952), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 178, 126, 136, and 78, respectively.

TABLE IV

CORRELATION OF HUMAN BODY WEIGHT AT DIFFERENT AGES OR STAGES BETWEEN BIRTH AND EARLY ADULTHOOD

Age (years) or stage	N	r^a	Age (years) or stage	N	r^a
		Infancy through early childhood			
Birth with 0.5	1174	.44	Birth with 3[b]	700	.42
Birth with 1	3623	.41	Birth with 5[c]	373	.33
1 with 2	828	.81	2 with 5	518	.79
		Middle childhood through adolescence			
6 with 9	602	.88	6 with 14[d]	156	.66
6 with 11[d]	232	.80	12 with EAW[e]	186	.71[f]
6 with 12[f]	220	.78	14 with EAW	192	.82
		Infancy and childhood with early adulthood			
Birth with EAW	399	.35	4 with EAW	302	.47
1 with EAW	429	.38	9 with EAW	293	.72

[a] Composite correlation coefficients derived from series of sex specific r's using z-transformation. Except as indicated, each pooling of r's is for both sexes.

[b] An additional study by Lowe and Gibson (1953) finds $r = .50$ on 1782 infants from correlating body weight at birth and age 3 years, with birth order and duration of prenatal period held constant.

[c] Cullumbine (1953) reports $r = .42$ on 327 children for the association of body weight at birth and age 6 years. This r may have been computed without regard to sex; if so, a lower r would be secured from combining the sex specific coefficients. Combining sex specific coefficients from Tuddenham and Snyder (1954) gives $r = .22$ on 133 children weighed at birth and age 6 years.

[d] Males only.

[e] EAW symbolizes early adult weight.

[f] Females only. For ages 7 years with 12 years, Wilson (1935) reports $r = .79$ on a sample of 275 females.

Identifying next the sources for that part of Table IV dealing with middle childhood and adolescence:

Ages 6 and 9 years, from Tuddenham and Snyder (1954) and Meredith (1961a). N's are 136 and 466, respectively.

Ages 6 and 11 years, from Tuddenham and Snyder (1954) and Meredith (1961a). N's are 66 and 166, respectively.

Ages 6 and 12 years, from Tuddenham and Snyder (1954) and Meredith (1961a). N's are 70 and 150, respectively.

Ages 6 and 14 years, from Tuddenham and Snyder (1954) and Meredith (1961a). N's are 66 and 90, respectively.

Age 12 years and EAW, from Bayley (1954), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 23, 70, and 93, respectively.

Age 14 years and EAW, from Bayley (1954), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 19, 66, and 107, respectively.

Component *r*'s for the part of Table IV treating relations between body weight in early adulthood (EAW) and body weight in infancy and childhood were gathered as follows:

Birth and EAW, from Bayley (1954), Tuddenham and Snyder (1954), Tanner *et al.* (1956), Reed and Stuart (1959), and McCammon and Hansman (1964). N's are 46, 133, 80, 130, and 10, respectively.

Age 1 year and EAW, from Bayley (1954), Tuddenham and Snyder (1954), Tanner *et al.* (1956), Reed and Stuart (1959), and McCammon and Hansman (1964). N's are 45, 135, 80, 130, and 39, respectively.

Age 4 years and EAW, from Bayley (1954), Tuddenham and Snyder (1954), Tanner *et al.* (1956), and Meredith (1961a). N's are 43, 136, 80, and 43, respectively.

Age 9 years and EAW, from Bayley (1954), Tuddenham and Snyder (1954), and Meredith (1961a). N's are 45, 136, and 112, respectively.

In all studies except two, "early adult weight" connotes body weight at age 18 years. Bayley (1954) employed weight values taken near the beginning of the second decade, and Tanner *et al.* (1956) weight values obtained in the last half of the second decade.

Discussion of the tabled size-size correlations will proceed from weak to strong associations. Moderately low positive relationships (*r*'s between .30 and .50) are found for magnitude of body weight (1) at birth and 6 months later; (2) at birth and ages 1 year, 3 years, and 5 years; also (3) in early adulthood and at birth, age 1 year, and age 4 years.

Moderately high positive relationships (*r*'s between .70 and .85) are found for magnitude of body weight (1) at age 2 years with ages 1 year and 5 years; (2) at age 6 years with ages 11 years on males and 12 years on females; and (3) in early adulthood with ages 9 years on both sexes, 12 years on females, and 14 years on males.

The highest value in Table IV is $r = .88$ for magnitude of body weight at ages 6 years and 9 years. This coefficient represents the shortest age span tabled within the period between middle childhood and early adulthood. As the age span in size-size correlation is reduced, Y-values are equivalent to X-values plus decreasing amounts for change in magnitude during the interval separating the two ages. Wilson (1935), Simmons (1944), and Tuddenham and Snyder (1954) report *r*'s above .90 for body weight at successfully paired annual ages from 6 years to 18 years. In infancy and early childhood, *r*'s above

.85 are found for ages 6 months with 1 year (Kasius *et al.*, 1957), and for adjacent annual ages between 2 years and 6 years (Simmons, 1944; Tuddenham & Snyder, 1954).

C. Size-Gain Correlations

In Table V correlation coefficients are presented for body weight at selected postnatal ages with absolute (kilogram) and relative (percentage) increment in body weight during subsequent age intervals. Integrative discussion of these coefficients will focus on three zones of association.

TABLE V
Correlation of Human Body Weight at Selected Ontogenetic Ages or Stages with Gain in Body Weight during Ensuing Periods

Row number	Age (years) or stage	Ensuing period	Size and kilogram gain		Size and percentage gain	
			N	r^a	N	r^a
1	Birth	Birth to 0.5	404	−.17	133	−.68
2	Birth	Birth to 1	1178	−.05	389	−.70
3	Birth	Birth to 5	259	.07	259	−.68
4	Birth	Birth to 18	273	.20	273	−.59[b]
5	1	1 to 2	782	−.06	549	−.45
6	1	1 to 5	330	.15	330	−.36
7	1	1 to 18	304	.26	304	−.42
8	3	3 to 5	406	.20	406	−.12
9	5	5 to 9	500	.57	500	.26
10	5	5 to 11[c]	166	.51	166	.14
11	6	6 to 12[d]	220	.56	220	.16
12	6	6 to 14[c]	156	.47	156	.06
13	9	9 to 18	231	.21	231	−.50

[a] Composite correlation coefficients derived from series of sex specific r's using z-transformation. Except as indicated, each pooling of size-gain r's is for both sexes.

[b] The scatter diagrams for body weight at birth with percentage gain in body weight from birth to age 18 years indicated slight curvilinearity. Correlation ratios (Eta for X on Y in each instance) are .64 on males and .61 on females.

[c] Males only.

[d] Females only.

Associations are near zero for body weight at birth with absolute gain during the first postnatal year (row 2), body weight at birth with absolute gain during the first postnatal quinquennium (row 3), body weight at age 1 year with absolute gain during the ensuing year (row 5), body weight at age 1 year

with absolute gain in the succeeding quadrennium (row 6), body weight at age 3 years with relative gain in the subsequent biennium (row 8), body weight at age 5 years with relative gain in the subsequent sexennium (row 10), and body weight at age 6 years with relative gain in the ensuing 6 to 8 years (rows 11 and 12).

There are negative associations above $r = -.40$ for body weight at birth with percentage increase during early infancy (rows 1 and 2), body weight at birth with percentage increase from birth to early adulthood (row 4), body weight at age 1 year with percentage increase in late infancy (row 5), body weight at age 1 year with percentage increase from this age to early adulthood (row 7), and body weight at age 9 years with percentage increase from this age to early adulthood (row 13). The highest coefficient tabled is $r = -.70$, registering moderately strong inverse association of weight at birth and percentage increment in weight during the first postnatal year.

There are positive relationships near $r = .50$ for body weight in middle childhood with kilogram gain during late childhood and early adolescence (rows 9, 10, 11, and 12). Since the highest positive coefficient is $r = .57$, it follows that at no age in infancy or childhood does magnitude of body weight closely presage velocity of subsequent change in body weight.

For the column of correlations in Table V on size and percentage gain, N's were drawn as follows:

Row 1, 133 from Tuddenham and Snyder (1954).

Row 2, 126 from Low (1952), 133 from Tuddenham and Snyder (1954), and 130 from Reed and Stuart (1959).

Row 3, 126 from Low (1952) and 133 from Tuddenham and Snyder (1954).

Row 4, 133 from Tuddenham and Snyder (1954), 130 from Reed and Stuart (1959), and 10 from McCammon and Hansman (1964).

Row 5, 51 from Maresh and Washburn (1938), 126 from Low (1952), 135 from Tuddenham and Snyder (1954), and 237 from Meredith (1961a).

Row 6, 126 from Low (1952), 135 from Tuddenham and Snyder (1954), and 69 from Meredith (1961a).

Row 7, 135 from Tuddenham and Snyder (1954), 130 from Reed and Stuart (1959), and 39 from McCammon and Hansman (1964).

Row 8, 126 from Low (1952), 136 from Tuddenham and Snyder (1954), and 144 from Meredith (1961a).

Row 9, 136 from Tuddenham and Snyder (1954) and 364 from Meredith (1961a).

Row 10, 66 from Tuddenham and Snyder (1954) and 100 from Meredith and Meredith (1958).

Row 11, 70 from Tuddenham and Snyder (1954) and 150 from Meredith (1961a).

Row 12, 66 from Tuddenham and Snyder (1954) and 90 from Meredith (1961a).

Row 13, 136 from Tuddenham and Snyder (1954) and 95 from Meredith (1961a).

N's and sources for the columns of Table V pertaining to size and kilogram gain are the same as above with the following additions:

Row 1, 271 from Thompson (1954).

Row 2, 156 from Simmons and Todd (1938), 425 from Hammond (1952), 106 from Thompson (1954), and 102 from Millis and Cho-Yook (1957).

Row 5, 233 from Simmons and Todd (1938).

D. Gain-Gain Correlations

Table VI displays r's from correlating body weight increments for adjacent age intervals varying from 6 months to 17 years. In no instance is velocity during the segments of infancy and childhood studied (column 2) highly associated with velocity during the subsequent periods of pre-adult ontogeny (column 3).

TABLE VI

Correlation of Increase in Human Body Weight during Selected Ontogenetic Periods and Increase during Succeeding Periods

Row number	Earlier period	Later period	Kilogram increments		Percentage increments	
			N	r^a	N	r^a
1	Birth to 0.5	0.5 to 1	560	.10	133	−.24
2	Birth to 1	1 to 2	259	−.22	259	−.22
3	1 to 3	3 to 5	317	.04	317	−.18
4	3 to 5	5 to 9	184	.50	184	.24
5	6 to 9	9 to 12[b]	220	.45	220	.15
6	6 to 9	9 to 14[c]	155	.64	155	.30
7	Birth to 1	1 to 18	273	.18	273	−.26
8	1 to 5	6 to 18	133	.24	133	−.21
9	6 to 9	9 to 18	215	.24	215	−.26

[a] Composite correlation coefficients derived from series of sex specific r's using z-transformation. Except as indicated, each pooling of gain-gain r's is for both sexes.

[b] Females only.

[c] Males only.

In the periods of infancy and early childhood, coefficients from absolute and relative increments are between ±.25. Kasius *et al.* (1957), on a sample of 666 infants, report $r = .23$ from correlating absolute increments for the first

and second quarters of the first postnatal year. The coefficients in rows 1 to 3 of Table VI vary from near zero to $r = -.24$, the latter value representing association of relative increments for the first and second halves of the first postnatal year.

From early childhood to middle adolescence, there is moderate positive relationship between kilogram increases and low positive relationship between percentage increases. The *r*'s tabled in rows 4 to 6, based on gains in body weight during periods of 2 to 5 years, fall within the limits .45 to .65, and .15 to .30, for kilogram and percentage gains, respectively.

The remaining portion of Table VI pertains to growth rates during segments of the first decade of postnatal life correlated with growth rates extending from infancy and childhood ages through adolescence. Statistics are given relating gains in infancy with gains between infancy and early adulthood (row 7), gains in early childhood with gains from middle childhood to early adulthood (row 8), and gains in later childhood with gains spanning the adolescent years (row 9). In each instance the *r*'s from kilogram increments are low positive and those from percentage increments low negative.

The reader is asked to compare Table III and VI. It will be seen that, for the periods 1–3 years with 3–5 years, comparable *r*'s are .00 and .04 (absolute gains); for the periods 3–5 years with 5–9 years comparable *r*'s are .20 and .24 (relative gains); for the periods 1–5 years with 6–18 years comparable *r*'s are .11 and .24 (absolute gains), —.17 and —.21 (relative gains); and so forth.

N's and sources for the correlations assembled in Table VI are as follows:

Row 1, 133 from Tuddenham and Snyder (1954) for kilogram and percentage increments; also 427 from Kasius *et al.* (1957) for kilogram increments only.

Row 2, 126 from Low (1952) and 133 from Tuddenham and Snyder (1954).

Row 3, 126 from Low (1952), 133 from Tuddenham and Snyder (1954), and 58 from Meredith (1961a).

Row 4, 135 from Tuddenham and Snyder (1954) and 49 from Meredith (1961a).

Row 5, 70 from Tuddenham and Snyder (1954) and 150 from Meredith (1961a).

Row 6, 65 from Tuddenham and Snyder (1954) and 90 from Meredith (1961a).

Row 7, 133 from Tuddenham and Snyder (1954), 130 from Reed and Stuart (1959), and 10 from McCammon and Hansman (1964).

Row 8, 133 from Tuddenham and Snyder (1954).

Row 9, 135 from Tuddenham and Snyder (1954) and 80 from Meredith (1961a).

IV. Interage Relations for Other Anatomic Variables

A. Background Information

Correlation findings of the 3 varieties under consideration are available for more than 20 dimensions of the head and face, trunk, and limbs. Included are transverse diameters (widths of head, face, dental arches, hips, and shoulders), anteroposterior diameters (depths of head, face, dental arches, and foot), vertical distances (lengths of stem, nose, upper limb, and lower limb), and circumferential distances (girths of head, chest, arm, and leg). Stem length, sometimes called sitting height, is distance from the vertex of the head to the lower end of the trunk (Knott, 1941; Newcomer & Meredith, 1951).

Each of the above variables can be measured with high dependability. Assuming anthropometric training and rigorous laboratory procedures, reliability coefficients specific for age and sex lie largely above $r = .95$ (Knott, 1941; Meredith, 1955b). Head width, hip width (bi-iliocristal diameter), and leg girth are among the variables yielding reliability coefficients near $r = 1.00$, while coefficients for shoulder width and chest girth are near $r = .90$.

In Fig. 3 are plotted data for leg girth and head width on a single male (T.F.K.) measured at successive ages between birth and early adulthood. The curve for leg girth is a rising trend, with periods of rapid ascent in early infancy and early adolescence. Regarding these characteristics, the curve is similar to curves for stature and body weight (Figs. 1 and 2) and illustrative of curves for stem length, shoulder width, chest girth, hip width, and limb girths (Meredith, 1935; Boynton, 1936).

The curve for head width is practically an increasing monotonic trend, its rise being rapid during infancy, slower in early childhood and, throughout late childhood and adolescence, slow and almost linear. Curves for head depth and head girth are similar to this. For face width, the gross similarity holds, but the curve has greater positive slope during late childhood and adolescence (Meredith, 1954).

B. Size-Size Relationships

Kasius *et al.* (1957) have investigated interage associations in infancy for 6 measurements of the head, trunk, and lower limbs. Their findings, reproduced in Table VII, indicate that body size at the middle of the first postnatal year is less closely associated with size at birth than with size at age 1 year. The r's for size at birth and age 6 months lie between .20 and .60; those for size at ages 6 months and 1 year, between .65 and .80. (Comparable coefficients from the same study are .66 and .83 for stature, .43 and .86 for body weight.)

Relationships at paired infancy ages for thickness of the skin and subcutaneous adipose tissue are available from Tanner (1962). The data are "sums of the logarithmic transforms" of thickness measures taken at four sites, i.e., "over biceps, over triceps, sub-scapular, and supra-iliac." Coefficients reported are $r = .19$ for ages 1 month with 6 months, $r = .02$ for ages 1 month with 1 year, and $r = .54$ for ages 6 months with 1 year. N = 136 in each instance. Again weaker association is found in early infancy than late infancy.

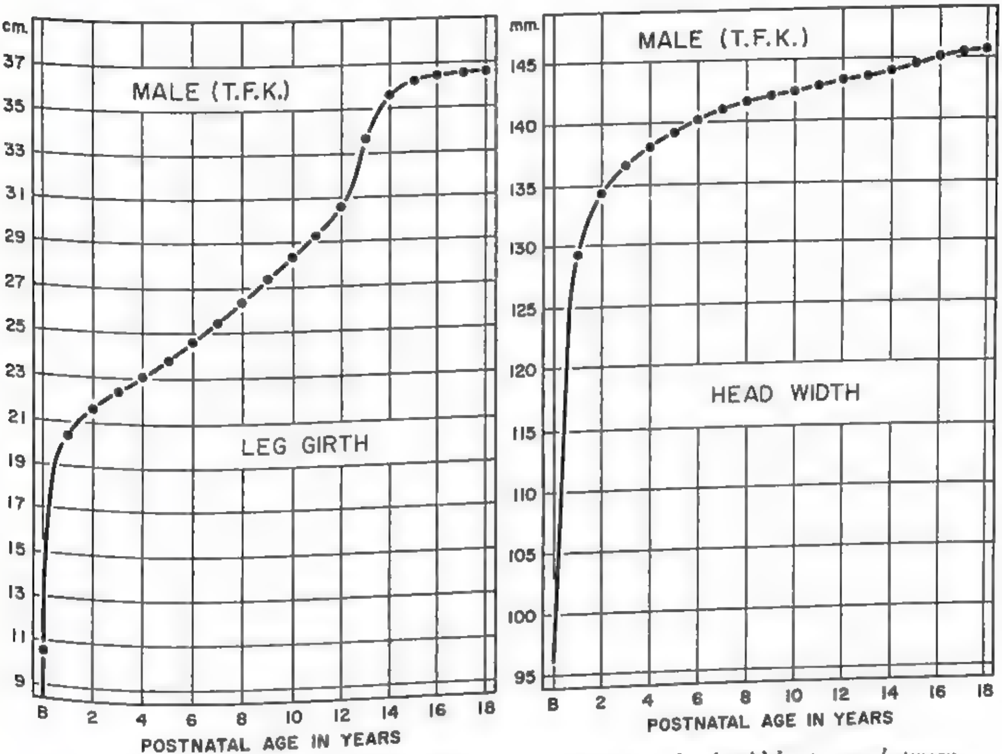

Fig. 3. Individual curves for magnitude of leg girth and head width at ages between birth and early adulthood.

Several studies done in the writer's laboratory include size-size r's for the childhood period. The ages paired are spaced by 4 to 6 years, and the variables are measurements of the head, trunk, and lower limbs. Combining sex specific coefficients for size at age 5 years with size at age 9 years, $r = .98$ for head width (Meredith, 1953), $r = .94$ for stem length (Carl, 1947), $r = .91$ for hip width (Meredith & Carl, 1946), $r = .94$ for upper limb length (Meredith, 1947), and $r = .75$ for arm girth (Meredith, 1961a). N's are 162, 55, 55, 56, and 195, respectively. Other pooled coefficients on the two sexes are $r = .90$ for face width at ages 5 years and 10 years (Meredith, 1954), $r = .87$

for width between the upper deciduous canine teeth at ages 4 years and 8 years (Holcomb & Meredith, 1956), and $r = .90$ for width between the lower deciduous second molar teeth at ages 4 years and 8 years (Meredith & Hopp, 1956). N's are 149, 100, and 77, respectively. Meredith (1955a), from a sample of 70 males measured at ages 5 years and 11 years, obtained r's of .91 and .81 for lower limb length and leg girth, respectively. Those of the foregoing childhood coefficients that pertain largely to osseous structures fall between .90 and .98; somewhat lower coefficients are found for arm and leg girths, measures including mainly soft tissues. In this regard, refer to childhood figures for stature and body weight (Tables I and IV).

TABLE VII
INTERAGE CORRELATIONS FOR 6 DIMENSIONS OF THE HUMAN BODY MEASURED AT BIRTH, 6 MONTHS LATER, AND 1 YEAR FOLLOWING BIRTH[a]

	Birth with 0.5		0.5 with 1		Birth with 1	
Measurement	N	r^b	N	r^b	N	r^b
Head girth	617	.56	418	.80	377	.51
Stem length[c]	531	.58	358	.80	315	.48
Chest girth	614	.40	413	.74	373	.38
Hip width	493	.33	347	.79	297	.33
Lower limb length	531	.51	357	.65	315	.48
Leg girth	196	.22	133	.73	92	.29

[a] After Kasius *et al.* (1957).
[b] Composite coefficients were derived from sex specific *r*'s by z-transformation.
[c] Distance from vertex of head to lower end of trunk.

Utilizing width and depth measurements of each dental arch on 29 children having good dental occlusion, Knott (1961) reports late childhood and adolescent associations. Coefficients representing size-size correlation at ages 9 years and 15 years (derived from sex specific *r*'s by z-transformation) are .91 for upper arch width, .86 for lower arch width and depth, and .80 for upper arch depth.

Table VIII presents interage correlations in the period from late childhood to early adulthood. These statistics are drawn from Tuddenham and Snyder (1954). Examination of the table, together with comparable portions of Tables I and IV, reveals that for stature, body weight, stem length, shoulder width, hip width, and leg girth obtained *r*'s fall between .65 and .85 for early adult magnitude with magnitude at ages 9 years (both sexes), 12 years (females), and 14 years (males). It is left for the reader to ascertain additional generalizations.

Exhibited in Table IX are *r*'s from Tanner *et al.* (1956) denoting size-size relationships for 6 anatomic variables measured in infancy, early childhood, and early adulthood. For the head, trunk, and limb dimensions of this table,

TABLE VIII

INTERAGE CORRELATIONS FOR 4 DIMENSIONS OF THE HUMAN BODY MEASURED AT AGES BETWEEN LATE CHILDHOOD AND EARLY ADULTHOOD[a]

Measurement	Size-size r's for ages (years):				
	9–12[b]	12–18[b]	9–14[c]	14–18[c]	9–18[d]
Stem length	.88	.72	.78	.85	.80
Shoulder width	.85	.81	.67	.76	.71
Hip width	.91	.72	.81	.84	.76
Leg girth	.93	.82	.86	.82	.73

[a] After Tuddenham and Snyder (1954).
[b] Females only; N = 70.
[c] Males only; N = 66.
[d] Values for both sexes obtained from sex specific r's by z-transformation; N = 136.

TABLE IX

INTERAGE r'S[a] FOR 6 DIMENSIONS OF THE HUMAN BODY MEASURED AT AGES IN INFANCY, EARLY CHILDHOOD, AND EARLY ADULTHOOD[b]

Measurement	Birth with 1 year	2 with 5 years	Birth with EAV[c]	5 years with EAV[c]
Head width	.29[d]	.84	.26	.82
Head depth[e]	.30	.82	.23	.79
Shoulder width[f]	.03	.31	.18	.18
Hip width	.13	.36	.23	.34
Forearm length[g]	.26	.81	.25	.68
Foot depth[e]	.40	.59	.42	.50

[a] Obtained from sex specific r's by z-transformation; each composite coefficient is based on N = 80.
[b] After Tanner *et al.* (1956).
[c] EAV symbolizes early adult value; more specifically, magnitude of each dimension in the age period 25–30 years.
[d] For N = 80 and confidence level .05, the hypothesis that a population r is zero can be rejected where sample r exceeds .22.
[e] Body depths are anteroposterior diameters.
[f] The flexibility of the shoulder girdle makes it more difficult to obtain highly reliable measures of shoulder width than of most other body widths, lengths, and depths (Knott, 1941).
[g] Distance from elbow to tip of middle finger, hand extended.

also for stature (Table I) and body weight (Table IV), relationships in respect to size at birth and in early adulthood are between $r = .15$ and $r = .45$. Further reference to Table IX awaits the comparative or integrative bent of specific readers.

Maresh (1955) has reported a relevant study utilizing length measurements determined roentgenographically on the 6 bones of the arm, forearm, thigh, and leg. Rather than the method of correlation, the method was that of computing percentile ranks for a given variable at successive ages and graphing the

age-to-age positional shifts of individuals within the peer group. Graphic inspection showed less change in rank order (higher interage association) during middle and late childhood than during "infancy or adolescence."

C. Size-Gain Relationships

Magnitude of head girth and stem length at 0.5 months after birth in relation to centimeter increase of each measurement between this age and age 6 months has been investigated by Thompson (1956). Combination of the sex specific statistics obtained yields $r = -.47$ for head girth and $r = -.56$ for stem length. In each instance N = 230.

Table X presents correlation coefficients derived from data for 7 body dimensions amassed by Low (1952) on 126 children measured at birth and subsequently at ages 1 year and 5 years.

TABLE X
COEFFICIENTS[a] FROM CORRELATING SIZE OF 7 BODY DIMENSIONS AT SELECTED INFANCY AGES WITH INCREMENT IN EACH DIMENSION DURING SUBSEQUENT INTERVALS[b]

	Size and centimeter gain		Size and percentage gain	
Measurement	B with B-1[c]	1 with 1–5[d]	B with B-1[c]	1 with 1–5[d]
Head width	−.47	−.37	−.65	−.46
Head depth[e]	−.34	−.42	−.53	−.52
Face width	−.55	−.63	−.65	−.68
Stem length	−.44	−.09	−.62	−.33
Forearm length[f]	−.18	−.14	−.32	−.47
Hip width	−.30	−.49	−.49	−.64
Foot depth[e]	−.30	−.31	−.49	−.58

[a] Obtained from sex specific r's by z-transformation; each composite r is based on N = 126.
[b] After Low (1952).
[c] Size at birth with gain during the first postnatal year.
[d] Size at age 1 year with gain in the ensuing quadrennium.
[e] Body depths are anteroposterior diameters.
[f] Distance from elbow to tip of middle finger, hand extended.

The predominant generalization revealed by this table is low to moderate negative association between body size in infancy and increase in body size during infancy and early childhood. For size at birth and absolute increment during the first postnatal year, the obtained r's vary from —.18 to —.55. Slightly higher relationships (—.32 to —.65) are found for size at birth and relative increment during the first postnatal year. Comparable values representing stature and body weight (Tables II and V) are —.30 and —.05 for size and absolute gain, —.58 and —.70 for size and relative gain.

Interage Relations of Anatomic Measures

Holcomb and Meredith (1956) and Meredith and Hopp (1956) studied associations for magnitude of dental arch widths at age 4 years and absolute change in these widths during the ensuing quadrennium. The obtained r's are near zero (—.08 to +.02) from the upper and lower arches measured in the regions of the deciduous canine and second molar teeth. Magnitude of upper face width at age 4 years and centimeter change in this dimension over the succeeding quinquennium has been found to approximate r = —.25 (Meredith, 1954). These facial findings are based on samples of 77 to 100 children.

Several dimensions of the stem and limbs have been utilized in investigating relations between size at age 5 years and increment over the ensuing quadrennium. In respect to size and centimeter gain, obtained r's are .28 for stem length (Carl, 1947), .28 for hip width (Meredith, 1961a), .56 for lower limb length (Carl, 1947), .35 for upper limb length (Meredith, 1947), and .31 for arm girth (Meredith, 1961a). Correlation of size and percentage gain yields .12 for hip width, —.20 for upper limb length, and .17 for arm girth. N's are 55 each for stem length and lower limb length, 56 for upper limb length, and 195 each for hip width and arm girth.

Reproduced in Table XI are size-gain r's for males (Meredith & Meredith, 1958) based on data gathered at both ends of a childhood sexennium. Mag-

TABLE XI

MAGNITUDE OF 13 BODY DIMENSIONS ON MALES AGE 5 YEARS CORRELATED WITH GAIN IN EACH DIMENSION DURING THE ENSUING SEXENNIUM[a]

Measurement	Size and centimeter gain		Size and percentage gain	
	r	P[b]	r	P[b]
Head width	.05	...	−.13	...
Head depth	−.09	...	−.28	<.01
Face depth[c]	.13	...	.02	...
Upper face width	.09	...	−.27	<.01
Lower face width[c]	.17[d]	...	−.18[d]	...
Nose length[c]	−.03	...	−.35	<.01
Stem length	.23	<.05	−.11	...
Lower limb length	.56	<.01	.02	...
Shoulder width	.13	...	−.23	<.05
Hip width	.23	<.05	−.03	...
Chest girth	.36	<.01	.23	<.05
Arm girth	.41	<.01	.24	<.05
Leg girth	.35	<.01	.11	...

[a] After Meredith and Meredith (1958).
[b] Probability that r from the sample would be as large as obtained if population r were zero.
[c] N = 57 for these variables; for all remaining variables, N = 100.
[d] On a sample of 36 females, Newman and Meredith (1956) obtained comparable size-gain r's of .18 and —.07, respectively.

nitude at age 5 years in 13 dimensions of the head, trunk, and limbs is correlated with increment in each dimension from age 5 years to age 11 years. The coefficients for magnitude with absolute increment fall between —.09 and +.56; those for magnitude with relative increment lie between —.35 and +.24.

Synthesizing in regard to the childhood years (taking account of the 20 anatomic measurements considered in the preceding paragraphs and in Tables II, V, and XI), associations vary from zero to moderate positive for size and centimeter increase, and from low negative to low positive for size and percentage increase.

TABLE XII

COEFFICIENTS[a] FROM CORRELATING SIZE OF 4 BODY DIMENSIONS AT AGE 9 YEARS WITH INCREMENT IN EACH DIMENSION DURING SUBSEQUENT PERIODS[b]

	Size and centimeter gain		Size and percentage gain	
Measurement	9 with 9–13[c]	9 with 9–18[d]	9 with 9–13[c]	9 with 9–18[d]
Stem length[e]	.31[f]	−.01	.14	−.33
Shoulder width	−.01	−.37	−.24	−.64
Hip width	.31	.03	.12	−.28
Leg girth	.17	−.16	−.08	−.47

[a] Obtained from sex specific r's by z-transformation.
[b] Tuddenham and Snyder (1954).
[c] Size at age 9 years with gain in the ensuing quadrennium.
[d] Size at age 9 years with gain during the succeeding 9 years.
[e] N's are 136 for stem length and shoulder width, 135 for hip width and leg girth.
[f] For N = 135 and confidence level .05, the hypothesis that a population r is zero can be rejected where sample r exceeds ±.17.

Knott (1961) studied relationships between size of each dental arch at age 9 years and absolute change (gain or loss) during the sexennium from age 9 years to age 15 years. Obtained r's, from a sample of 29 children having acceptable dental occlusion, are —.15 for upper arch width, —.12 for upper arch depth, —.41 for lower arch width, and —.22 for lower arch depth. Only the r of —.41 is significant at the 5% level of confidence.

Measures of stem length, shoulder width, hip width, and leg girth, accessible from Tuddenham and Snyder (1954), were used to compute the statistics in Table XII on size at age 9 years in relation to gain from this pre-adolescent age to (a) mid-adolescence and (b) early adulthood. Coefficients for size at age 9 years and gain from 9 to 13 years are between —.24 and +.31. Consistent with the prior findings on stature and body weight (Tables II and V), weak to moderately strong negative associations are found for magnitude at age 9 years with relative increment between this age and early adulthood.

D. Gain-Gain Relationships

Relationships between centimeter increases in the first and second halves of the first postnatal year are available from Kasius *et al.* (1957) for 6 measurements on the stem and limbs. The obtained *r*'s, all negative and weak, are —.20 for stem length, —.19 for hip width, —.39 for lower limb length, —.11 for head girth, —.18 for chest girth, and —.33 for leg girth. N's are 306, 284, 306, 369, 364, and 88, respectively.

Both absolute and relative increments in infancy and early childhood are accessible for 7 measurements of the stem and limb from Low (1952). Correlation of increment in the first postnatal year with that in the ensuing quadrennium gives coefficients (N = 126) varying from near zero to —.60. Specifically, the *r*'s from centimeter gains are —.24 for head width, —.42 for head depth, —.57 for upper face width, —.08 for stem length, —.52 for hip width, —.17 for forearm length, and —.23 for foot depth. Corresponding percentage gain *r*'s for the period birth to 1 year with the period 1 year to 5 years are —.23, —.46, —.54, —.22, —.60, —.44, and —.37, respectively.

For childhood bienniums extending from ages 5 years to 7 years and 7 years to 9 years growth rate correlations fall between ±.40. Utilizing centimeter increases, Meredith (1947, 1961a) obtains *r*'s of .08 for stem length, .34 for hip width, .24 for lower limb length, —.16 for upper limb length, and .37 for arm girth. Corresponding coefficients based on percentage increases are .01, .19, .01, —.33, and .24. N = 56 in respect to upper limb length and 195 in respect to each of the other variables. Obtained gain-gain *r*'s for nose length, representing the biennium 5 years to 7 years and the succeeding quadrennium, are .18 and .15 from absolute and relative values, respectively (Meredith, 1958). N = 80 for nose length.

Correlation of absolute increments during the trienniums from ages 5 years to 8 years and 8 years to 11 years have been studied for two dimensions of the face (Meredith, 1959, 1961b) and two dimensions of the lower limbs (Meredith, 1955a). Positive associations between .40 and .60 are found; explicit *r*'s are .50 for face depth, .44 for lower jaw depth, .54 for lower limb length (males only), and .59 for leg girth (males only). N's, in like sequence, are 125, 132, 70, and 70. Returning to the study of face depth, *r* = .50 from correlation of either absolute or relative increments.

Knott (1961) correlated absolute changes in dental arch width during the biennium 9 years to 11 years and the subsequent quadrennium. On 29 children with good occlusion, changes in these periods were determined for maximum diameter of each dental arch at the permanent first molars. The obtained *r*'s are low, .21 from the upper arch and .13 from the lower arch.

Gain-gain relationships pertaining to 4 measurements of the stem and limbs

are available from Tuddenham and Snyder (1954) for the age periods 9 years to 13 years and 13 years to 18 years. Coefficients, computed from centimeter and percentage gains, respectively, are —.62 and —.64 for stem length, —.47 and —.54 for hip width, —.37 and —.31 for leg girth, and —.44 in both instances for shoulder width. Taking account of the findings for stature and body weight presented in row 8 of Table III and row 9 of Table VI, it is reasonable to infer that the above associations embody some negative strengthening produced by the wide age variation of circumpuberal acceleration. There are intergrades from (a) individuals whose stem and limb dimensions increase in the age period between 9 years and 13 years at the slower velocities characteristic of late childhood to (b) individuals whose stem and limb dimensions are beyond circumpuberal peak velocity by age 13 years and increase little thereafter.

V. Summary

The objective in this chapter is to integrate research findings on three kinds of association between anatomic variables. Consideration is delimited to types of interage and interstage association within the two decades of human ontogeny extending from birth to early adulthood.

Materials are drawn from more than 50 investigations, including 35 completed during the last 12 years. The primary substance of the chapter is reducible to three series of documented generalizations grouped in respect to each kind of relationship chosen for colligation and synthesis of studies.

Generalizations from size-size correlation are:

1. There is low positive association of body size at birth and body size in early adulthood. Product-moment coefficients approximate $r = .35$ for weight (Table IV), $r = .30$ for stature (Table I), and $r = .25$ for head width and depth, hip width, and forearm length (Table IX).

2. Similarly low relationships hold regarding measures of body magnitude at birth and age 5 years. The r's for stature and weight are each near .30 (Tables I and IV).

3. Body size 1 year after birth has low to moderate positive correlation with body size at birth. Obtained r's approximate .50 for stature and its stem and lower limb components (Tables I and VII), and .40 for weight, chest girth, and foot depth (Tables IV, VII and IX). Coefficients are between .30 and .50 for head dimensions, and between .10 and .30 for hip width, forearm length, and leg girth (Tables VII and IX).

4. The weak association of anatomic variables measured at the beginning and close of the first postnatal year gradually changes to strong association in childhood. Size-size r's representing consecutively paired annual ages from middle childhood to early adulthood exceed .90 for stature and weight. Mag-

nitude values at ages 6 years and 9 years yield r's of .96 for stature (Section II, B) and .88 for weight (Section III, B).

5. Beyond childhood there is lessening of the high positive correlations for external body size at age 6 years and a triennium later. In reference to size at age 6 years and in mid-adolescence (age 12 years on females, 14 years on males) coefficients are near .80 for stature (Table I) and near .70 for weight (Table IV). From measures of stature, weight, stem length, shoulder width, hip width, and leg girth, r's fall between .70 and .80 for size in early adulthood and size in middle or late childhood (Tables I, IV, and VIII).

From size-gain correlation, generalizations are:

1. At no age in infancy, childhood, or adolescence is magnitude of an anatomic variable highly related to its subsequent augmentation. The highest positive coefficients obtained are $r = .57$ for weight at age 5 years with kilogram increment in the ensuing quadrennium (Table V), and $r = .56$ for lower limb length at age 6 years with centimeter increment in the ensuing sexennium (Table XI).

2. There is low to moderate negative association between body size at birth and increase in body size during the first postnatal year. Specific r's are lower for size and absolute increase than for size and relative increase. Examples of the former are —.30 for stature (Table II), —.05 for weight (Table V), and —.18 to —.55 for head width, head depth, face width, stem length, forearm length, hip width, and foot depth (Table X). Corresponding r's for size and relative velocity (percentage gain) are —.58, —.70, and —.32 to —.65.

3. For size and absolute gain, the negative relationship in infancy changes in childhood to (a) zero relationship for dimensions of the head and (b) low to moderate positive relationship for stature, weight, and dimensions of the trunk and limbs. Coefficients on males for size at age 6 years with absolute increment in the subsequent sexennium are near zero for head width, head depth, face width, and nose length (Table XI), and between $r = .20$ and $r = .60$ for stature (Section II, C), weight (Table V), chest girth, hip width, arm girth, and leg girth (Table XI). For size and percentage gain, the moderately strong negative correlations in infancy change in childhood to coefficients within the zone from low negative to low positive (Sections II, C, III, C, and IV, C).

4. Size at birth has (a) practically no relation with centimeter or kilogram increment from birth to early adulthood and (b) moderate negative relation with percentage increment from birth to early adulthood. Specific r's are .04 for neonatal stature with centimeter increases postnatally (Table II), .20 for neonatal weight with kilogram increase over the succeeding 18 years (Table V), —.65 for neonatal stature with percentage gain postnatally (Table II), and —.62 for neonatal weight with percentage gain to age 18 years (Table V). Associations are roughly similar for size at age 9 years with increments from 9 years to 18 years; coefficients from data for weight, stem length, hip width,

and leg girth fall between ±.20 for size and absolute gain, and between —.25 and —.50 for size and relative gain (Tables V and XII).

Lastly, generalizations from gain-gain correlation are:

1. Association of anatomic absolute increments for the two halves of the first postnatal year varies from near or at zero to low positive. Obtained coefficients are —.39 for lower limb length, —.33 for leg girth, and between ±.20 for stature, stem length, head girth, chest girth, hip width, and weight (Sections II, D, IV, D, and Table VI).

2. Anatomic relationships are weak or lacking from (a) correlation of gains during the first and second postnatal year, and (b) correlation of gains during bienniums extending from ages 1 year to 3 years and 3 years to 5 years. For stature and weight, *r*'s are between .16 and —.22 for absolute gains and between —.01 and —.22 for relative gains (Tables III and VI).

3. Percentage increases in body dimensions show (a) moderate to low negative correlation from values for the first postnatal year and the period between ages 1 year and 5 years and (b) low to zero correlation from values for the biennial age intervals 5 years to 7 years and 7 years to 9 years. From data for several dimensions of the stem and limbs the former conclusion is supported by *r*'s between —.60 and —.20 and the latter conclusion by *r*'s distributed from —.33 through zero to +.24 (Section IV, D).

4. There is moderate to low positive association between absolute increases in successive segments of childhood. For the biennium from ages 3 years to 5 years with the quadrennium from ages 5 years to 9 years, obtained *r*'s are .40 for stature (Table III) and .50 for weight (Table VI). Similarly, for the trienniums from ages 5 years to 8 years and 8 years to 11 years, obtained *r*'s are .44 for lower jaw depths, .50 for face depth, .54 for lower limb length, and .59 for leg girth (Section IV, D). Coefficients are lower for the biennial periods from ages 5 years to 7 years and 7 years to 9 years; examples are .34 for hip width, .24 for lower limb length, and .08 for stem length (Section IV, D).

5. Correlating either absolute or relative values, relationships are low between anatomic increments for (a) the first postnatal year and the span from infancy to early adulthood, (b) the period between ages 1 year and 5 years and the span from middle childhood to early adulthood, and (c) the period between ages 6 years and 9 years and the span from late childhood to early adulthood. Specific *r*'s for stature and weight all lie between —.26 and +.24 (Tables III and VI).

Beside contributing to the fund of knowledge on child somatology, the contents of this chapter provide resources for corrective and exploratory activities. On the corrective side, numerous reported findings constitute grounds for modifying commonplace textbook statements on the prediction of stature, the positive correlation of body size and expected growth rate, and the expectation

of high consistency prior to adolescence for the ranking of well children in velocity ("progress") distributions. On the exploratory side, ontogenetically broad documentation of the lack of high gain-gain and size-gain associations becomes provocative both in construction of biological theory and in planning new avenues of somatological research.

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